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CURRENT CONSIDERATIONS OF WAR SURGERY*

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APPROXIMATELY three years ago to the day, this country was suddenly and furiously plunged into war. Since then many impressive developments have taken place both in the character and progress of the war and in the methods and procedures utilized in its prosecution. Three years of combat experience have stripped us of many encumbering and awkward practices and have provided us with more proficient qualities in waging war. Similarly, in the areas of the war in which we as surgeons are principally concerned, namely, the care of the wounded, combat experience has exerted its inevitably progressive influence. The concentrated experience and the accelerated activity that accompany war permit a more rapid evaluation of the methods and procedures that are applied, and tend to produce early improvements and advances. Measures that prove ineffectual are soon discarded and those found efficacious are just as quickly adopted. This accounts for the changes in concepts and modifications in military surgical practices that have occurred during the past three years of combat experience.

It seems fitting at this time to review, in the light of this and previous experience, some of these developments, to assess the value of procedure adopted, and to indicate the trends in surgical thought on the care of the wounded as obtained from and reflected by all sources available to The Surgeon-General's Office. Proper appraisal of current practice demands comparison with previous experience and, for this reason, it has been deemed desirable to refer wherever it has seemed pertinent to methods and views of previous wars. It is a curious but interesting observation that many of the methods and procedures finally adopted at the close of the last war "had been attempted by surgeons in bygone wars." As emphasized recently by Major General Philip Mitchiner: "It is a great pity that our surgeons and would-be surgeons had not acquainted themselves with the Official History of the War of 1914–18 concerning the Medical Services and the principles and practices during that period," for again in this war, as will be shown below, there has been some evident disregard of the experience gained and lessons learned in the last war. As commented previously, learning preferably by immediate and often bitter experience would seem to be not an uncommon human frailty.[4]

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SHOCK

Shock has long been considered one of the most serious problems facing the military surgeon, and at the onset of this war great confidence was placed in its therapeutic solution by the development of plasma. Although the development of plasma has undoubtedly been a great contribution, its usefulness in shock therapy can now be viewed in proper perspective. Unfortunately, the early enthusiasm that accompanied this development was so forceful that it pushed aside sound clinical judgment and led to the widespread misconception that plasma could be used as an effective and complete physiologic substitute for whole blood in the management of shock in the seriously wounded. This misconception became so firmly entrenched in the minds of both administrative and professional personnel that it somewhat handicapped the organization and development of more effective measures for the management of shock. With increasing experience in the treatment of shock, it became more and more evident that plasma could not be used as a complete substitute for whole blood. It was found that while seriously wounded men could be brought out of shock with plasma, they were frequently unable to withstand the life-saving surgery that was subsequently necessary. Superficially, such patients appeared ready for surgery, but it was soon realized that this appearance gave a false sense of security for even movement of the patient, anesthesia, and other procedures in preparation for surgery often caused the patient to fall back into shock. It soon became evident that whole blood transfusion was essential for the proper resuscitation of these patients and that whole blood is the only therapeutic agent that will prepare seriously wounded patients to withstand the surgery that is essential for the saving of life and limb. It was further demonstrated that whole blood transfusion at the time of initial treatment will reduce the incidence and morbidity of wound infection during convalescence.

Shock in the great majority of battle casualties is accompanied by considerable loss of blood. The reduced blood volume is due to the loss of both the cellular and the fluid elements of the blood. In such cases, the use of plasma may restore the blood volume but the oxygen-carrying capacity of the circulating blood remains embarrassed. For this reason, the transfusion of whole blood is more effective because it not only supplements the circulating blood volume but it also replenishes its oxygen-carrying capacity. In shock that is accompanied by little or no loss of blood, such as occurs in the early stages of burns, crushing injuries, extreme dehydration, or excessive visceral manipulation, the use of plasma may be considered preferable. Unfortunately, this type of shock is relatively infrequent in warfare.

The great military advantage of plasma lies in the fact that it can be used in situations where the procurement of whole blood is impractical. Its use, under such circumstances, is invaluable for, even in hematogenic shock, it can restore the circulating blood volume and thus, by preventing or reducing the effects of shock, tide the patient over the critical period which may be required for evacuation to a hospital or some other installation where

whole blood is available and life-saving surgery can be performed. Thus, the sobering light of actual experience has delineated more clearly the indications and the rationale of both plasma and whole blood. They are both extremely valuable in the management of shock, but they have their individual and specific purposes and, to be efficacious, must be used accordingly. The change in attitude of Army surgeons toward the use of whole blood can be illustrated by the fact that the present ratio of its use to that of plasma is one to one in contrast to the ratio of one to three in the earlier phases of the war. In the seriously wounded the amounts of whole blood required is even greater than this ratio would indicate. The recent development of the unprecedented program of shipping blood by air from this country directly to our hospitals on the fighting fronts further underlines the importance of whole blood transfusion.

Plasma, of course, was not available in the last war, although its use was suggested.[33] However, the value of whole blood transfusion in the treatment of shock in the seriously wounded was fully recognized. Moreover, whole blood transfusion was employed then in much the same way as now, albeit on a much less extensive scale. Thus, in discussing the problem of providing ample supplies of whole blood for transfusion at the front, it was stated in the British Official History of the last war that: "It was felt that if whole blood could be drawn off from donors during times of inactivity and stored ready for use during 'rush' periods, one of the disadvantages of transfusion, namely, the time absorbed in its performance, would be obviated. The giving of blood would then make no more demand on the overworked surgical staff than the giving of a saline infusion. . . ." [11] After it has been demonstrated that: "Blood, when received into a solution of dextrose and sodium citrate and kept cold could be preserved for several weeks," the principle was tested under war conditions and found satisfactory. In describing the use of this method in the Divisional Area, it was further stated that: "A store of preserved blood was kept at the center from which supplies could be drawn for transfusion in the forward area." "This plan of preparing beforehand bottles of citrated blood ready for use was carried out with great success during the heavy fighting in the summer and autumn of 1918."[11]

There is one other feature of shock that deserves consideration and has perhaps not been sufficiently appreciated. This is concerned with the lethal sequelae of shock. During peacetime shock is observed relatively infrequently and experience with the condition never approaches the massive scale that occurs in war. The lethal sequelae are, therefore, less evident and tend to be less impressive. In war, however, experience with the condition mounts rapidly and attention is directed more forcibly toward these sequelae. Moreover, because of certain conditions imposed by war, wounded men may be in a state of shock with reduced circulating blood volume for a period of hours. The ample use of plasma and whole blood may permit their resuscitation and even the performance of surgical procedures. Despite this, a number of these cases have been observed to die with manifestations of anuria or reduced urinary output. With more effective methods of resuscitation and

improved standards of surgery, these lethal sequelae of shock are becoming more apparent. They may be attributed essentially to asphyxia of organs or tissues during the prolonged period of reduced volume flow of blood. Irreparable damage from shock in such delayed deaths has been demonstrated in the brain, the kidney, and possibly the liver. The urinary suppression in these cases may also be associated with kidney damage resulting from the accumulation and deposition in this organ of liberated hemoglobin or myoglobin in the circulation. Still another factor that may play an important rôle in the impairment of kidney function in these cases is the presence of sulfonamides. It has not yet been ascertained which of these agents or their combinations is responsible for the serious kidney damage. Field studies are being conducted which, it is hoped, will throw further light on this interesting problem.

WOUND MANAGEMENT

The most common errors in the management of war wounds have been concerned essentially with an inadequate concept of the term *"débridement,"* an insufficient realization of the importance of leaving war wounds open or of the proper application of dressings in those left open, and the failure to recognize the need for splitting or bivalving encasements. All of these mistakes were observed in the last war and the essential principles of wound management which have now been finally adopted, at a higher level and on a much greater scale than ever before, were arrived at, perhaps more painfully, in the last war.

Much confusion has arisen about the terms *"débridement"*, *"epluchage"*, *"parage"*, "wound revision", "wound excision", and "wound trimming." There is an apparent need for an adequate expression of just what is meant by each term, particularly as regards the amount of tissue removed. Perhaps some of the confusion has evolved from the difficulty of putting into practice the original and idealistic procedure described, in 1897, by Friedrich, whose aim, on the basis of his experiments, was to remove bacteria from the wound by wide excision of the contaminated tissue in a single mass, such as is done for malignancy. This is a theoretical rather than a practical concept and the physiologically-minded surgeons, who recognize the wisdom of natural processes and know the full meaning of war wounds, find it difficult to accept this procedure as a practicable surgical maneuver. The practically-minded French surgeons have evolved a more realistic and rational procedure and use the term *"débridement"* to describe the opening of the wound[1] by incision in order to expose all recesses, which seems to approximate fairly closely the sense in which the term was originally used by Desault,[1] and by Larrey.[12] The terms *"epluchage"* and *"parage"* refer to the second step of the operation, *i.e.*, the removal of contaminated devitalized tissue. As indicated by the terms, *"epluchage"* may be described as a "peeling" of the inner surface of the wound and *"parage"* as a more radical "paring"; the distinction is quantitative and relates to the amount of tissue removed. In their effort to abandon the term "excision" and the concept associated with it, the British surgeons in the Mid-

dle East adopted the term "wound trimming." Unfortunately, this has led to further confusion and the misconception that all that was necessary was the removal of loose tags and readily available foreign bodies. Perhaps some have performed the procedure in this manner, but it does not conform with the definition of the operation as "the removal of foreign matter and dead tissue and the relief of tension by incisions planned to facilitate drainage".[8] It is clear from this definition that at least some British surgeons, like the French surgeons and others who have learned by actual experience, have merely rejected the original idealistic concept that assumes the feasibility of excision of the wound en bloc, and have accepted the more rational and practical procedure of eliminating those local conditions of the wound which contribute to the development of infection. Although some differences may exist as to the actual amount of tissue that should be removed or to the extraction of metallic fragments, there now seems to be fairly general accord among experienced war surgeons on certain principles, all of which became well recognized toward the close of the last war. The first of these is the provision of adequate exposure by incision. The track must be laid open throughout its extent. In most cases, this implies removal of the foreign body, for it is not otherwise possible to expose all recesses of the wound. Under certain circumstances where small shell fragments are unlikely to cause trouble and where their removal would unduly lengthen the operation and endanger the patient, it is perhaps best to leave the foreign body alone. The failure to perform this step in the operation, *i.e.*, free incision of the wound, is perhaps the most common mistake of the beginner and is often combined with another error, over-excision of the skin. This latter mistake, *i.e.*, the excessive removal of skin, probably stems from the original conception that included this as a part of the ritual of débridement when the wound is subsequently closed by primary suture. It is not only unnecessary when wounds are to be left open, but is actually harmful because it delays healing and increases the difficulties of secondary closure. The second important principle upon which all agree, and which interestingly enough was fully appreciated and emphasized by Botallo in the 16th century,[2] is the removal of all devitalized tissue in the wound. There may be some difference concerning the extent of this removal. Some, like the British, are more sparing of bruised tissue while others, like the French, who lean towards *"parage"* are perhaps more radical. It would seem from the descriptions given by Colonel E. D. Churchill,[6] the Surgical Consultant in North Africa and the Mediterranean Theater of Operation, that the procedure advocated and performed by the Americans, at least on that fighting front, is somewhat more radical than the *"epluchage"* of the French or the "wound trimming" of the British, and less radical than the *"parage"* of the French. If the principle of removal of all devitalized tissue is accepted, different usage of terms assumes academic significance only and the extent of the operation becomes a measure of the technical skill and clinical judgment of the surgeon. The third principle upon which there is complete agreement is drainage, *i.e.*, leaving all war wounds open. Despite constant emphasis and repeated publications, attempts to "get away with" closure are still observed, especially by sur-

geons recently arrived in battle areas. There has also been a tendency to occlude drainage by a tight pack of vaselined gauze rather than merely to keep the sides of the wound apart by loosely placed gauze. In this connection, recent studies indicate that fine-mesh plain gauze is perhaps superior to vaselined gauze, an observation that receives some support from the authors' experience. The fourth and final principle is immobilization, the significance of which was fully recognized by Hunter who stated that: "The first and great requisite for the restoration of wounded parts is rest, as it allows that action which is necessary for repair to go on without interruption." Here, too, there may be some divergence of opinion regarding the details of carrying out this principle. The use of plaster encasements has been found most satisfactory for this purpose, but padding and splitting or bivalving the encasement to avoid constriction has been considered essential although their omission have been common errors. The prolonged splinting of war wounds by the closed plaster method as conceived and used by Pirogoff in the Crimean War and by Ollier, Orr and Trueta in subsequent wars is no longer considered satisfactory for the majority of battle casualties. The tendency to veer away from the long-continued closed plaster treatment of war wounds is a natural consequence of the evolution of the more rational philosophy of wound management that places emphasis on early closure and healing through reparative surgery. The closed plaster treatment obviously does not fit into this program of wound management, since early inspection of the wound and efforts directed toward its closure by secondary suture or grafts precludes uninterrupted prolonged encasement. However, in certain types of injuries in which early closure is not feasible, such as in compound fractures, particularly those of the lower leg with large soft-tissue defect and established bone infection, it may still be applied.

Judged by the highest standards of civilian practice, the military environment precludes ideal surgical practice and imposes certain modifications upon the treatment of the wounded. In civilian life, the injured patient is hospitalized and operated upon within a few hours after injury. Since the average patient can remain in the hospital under close observation until his recovery, it is possible to perform a single operation consisting of two phases: first, the débridement or removal of all devitalized tissue, and then the surgical closure of the wound. In military surgery, the ideal conditions of civilian practice rarely exist. The time-lag between wounding and surgical treatment usually far exceeds the period within which "safe" initial closure of the wound is possible. Even were it possible to institute surgery within a few hours after wounding, the necessity for rapid evacuation in the interest of the mobility of the forward units would usually make it dangerous to institute primary closure immediately following initial wound surgery. Although a certain proportion of wounds treated in this manner would heal satisfactorily, it is not possible to know with certainty in which infection will develop. Primary closure enhances the development of life-endangering infection and interruption in the continuity of professional supervision imposed by evacuation precludes its early detection.

For these reasons, it has become a well-established principle of military surgery that wounds shall be left open after the initial débridement. Although the adoption of this rule has been justified as a safeguard against infection, the inevitable consequence has been a heavy penalty in the form of protracted convalescence and the formation of excessive scar tissue. Efforts to obviate these disadvantages have led to the development of a plan of wound management which constitutes, through its extensive application, a significant advance in military surgery.

This plan, so admirably described by Colonel Churchill,[5] is based upon a concept of wound management that provides the early routine closure by suture of wounds left unsutured at the initial operation. With the widespread use of secondary closure in wound surgery, the treatment of serious wounds has approached the ideal technic possible under nonmilitary conditions, the major differences being that the two phases of a single operation are separated into two distinct operations performed at different echelons of medical care. The initial phase, done in the forward area, is directed toward the prevention of infection and the preparation of the patient for transportation. Proper débridement of the wound minimizes the chances of infection and prepares the way for prompt and successful secondary suture following evacuation. Chemotherapy, as seen in the use of the sulfonamides and penicillin, is of value in reducing the extent and gravity of invasive infection, but it cannot take the place or minimize the importance of good primary surgery.

The next step in the care of the wound under this plan of wound management is the secondary, or what has been termed the reparative phase, usually done after the patient has been transported to a base hospital. If the initial wound operation has been complete, the wound may be closed by suture, usually at the time of the first dressing on or after the fourth day. The proper time for secondary closure by suture is determined by the gross appearance of the wound rather than by bacteriologic studies as was formerly considered necessary. This shift of emphasis from the microscopic to the clinical appraisal of the wound, which cuts across the lengthy arduous laboratory procedure that was previously considered a requisite for secondary suture, is a real advance in itself and is partly responsible for the practicability of secondary wound closure on a large scale. If there is evidence of slight infection, appropriate measures are taken to "clean-up" the wound prior to instituting secondary closure, usually a few days later. If the established infection is severe, or if the patient is toxic or anemic, a course of penicillin therapy and blood transfusion is instituted and followed by surgical revision of the wound and staged closure. The number of soft-part wounds closed in the manner described reach well into the thousands. Good healing has been recorded in from 90 to 95 per cent and no serious complications have been observed. The more complicated types of wounds, such as those involving bones or joints or those manifesting penetration of the viscera, require more elaborate care. In these wounds, there is greater danger of infection and penicillin has been relied upon to prevent infection during both stages of treatment and until the danger of infection is past.

Surgical procedures have been performed in this manner which, it is believed, would not otherwise have been possible. Also of importance in these cases is the recognition of the need for correcting secondary anemia from initial blood loss, for otherwise chronic infection is encouraged and healing delayed. In order to withstand the extensive corrective surgery which many of these patients require, adequate support by means of whole blood transfusion is essential.

Thus, it may be observed that a sound and significant concept in the surgical care of the wounded has been finally developed and now applied on a large scale. Healing is accelerated, restoration of function is hastened, and ultimate disability and deformity are minimized by this plan of wound management. Carried to its full extent, it is a plan that embraces three phases in the surgical treatment of the wounded, primary or initial, secondary or reparative, and tertiary or reconstructive. The first two are performed in the theaters of operation and the third is a function of specialized centers in general hospitals in this country. By properly coordinating these three phases in time and space, a closer approach to the ideal methods of wound management within the limits of a military setting is achieved.

While this plan of wound management, through its application on a more extensive scale and at a higher surgical level than ever before and through better integration of its phases, constitutes a real advance in military surgery, it is of interest to review previous experiences along these lines.[19-28] It would seem that here too there has been some lag in the effort made to utilize, from the last war, the "wisdom purchased at so tremendous a price." The slow, costly, and tedious progress that was made in this direction during the first three years of combat experience in the last war has been vividly portrayed in the British Official History, the pages of which read with greater currency than we are wont to admit.[3, 19] Eloquent evidence of this is afforded by the unanimous conclusions of the Inter-Allied Surgical Conference held in Paris in 1917, some of which are well worth quoting now:[19]

"(1) It is desirable that the organization of the Medical Service should be so directed as to permit of continuity in the supervision of the treatment of the wounded men.

"(2) Rapid transport to one of the casualty clearing stations is essential.

"(3) It is an advantage if each of these units has one or more advanced sections nearer to the firing line, for the reception of patients seriously wounded (such as those suffering from shock, profuse hemorrhage, wounds of the chest, abdomen, *etc.*).

"(4) All wounds of war must be considered to be either contaminated or infected.

"(5) The object of treatment should be:

"(a) To prevent development of infection if the wound is still in the stage of contamination, or to procure sterilization if infection has already developed.

"(b) To permit of secondary suture, when sterilization is realized.

"(6) In the primary treatment of the wound, excision of contused and lacerated tissue and the removal of fragments of clothing or foreign bodies must be considered as the rule except in certain cases where the patient cannot be kept under supervision.

"(7) When the wound has thus been properly prepared, primary suture may give good results, especially in the case of wounds of the joints. Primary suture is not to be undertaken unless the wound is only of some hours' standing (at the most eight hours), and only when the surgeon can retain the patient under his own observation for 15 days.

"(8) If primary suture be not undertaken, secondary suture should be performed when the clinical signs indicate that the wound is surgically sterile.

"(9) Several methods for the progressive sterilization of wounds are available, which allow of the routine practice of secondary suture."

These conclusions show a close parallel with recent trend of thought in wound management and towards the end of the last war this parallel appears even more striking. Greater and greater emphasis was placed on the very principles which we now stress. Thus, "in the primary treatment of wounds, it was abundantly shown that if the surgical or mechanical treatment had been sufficient it was practically immaterial what form of antiseptic was employed, or whether the wound was dressed with a solution of soap or simple sterile gauze."[19] As greater improvement in the primary treatment of wounds was achieved, the procedure of secondary suture became more common and "the results given show a record of complete success in from 75 to 90 per cent of the cases."[19] Even Carrel's bacterial count which was regarded as "the most important single element in furthering the progress of secondary suture" was "at a later period discounted and more or less discarded" for "the discovery was made that secondary union could be attained when the wound still contained numerous bacilli.[19] However, opinion on this point had apparently not yet fully crystallized for it is stated that "in spite of the assertion by many surgeons that a clinical inspection was sufficient to determine the suitability of a wound for secondary closure provided constitutional symptoms were absent, it remained a fact that the employment of the bacterial standard insured the largest proportion of successful secondary closures."[19]

CHEMOTHERAPY AND WOUND INFECTION

The glowing reports which were based upon and immediately followed the Pearl Harbor experience gave great impetus to the use of sulfonamide therapy as a means of controlling infection in war wounds.[23, 29, 31] As a result of this and other overenthusiastic reports, which were further heightened by the dramatic and publicity-wise efforts of the press and radio to single out sensational achievements, the impression became widespread, both in professional and lay minds that at last an effective antibacterial agent was found and that the great scourge of war wounds, wound infection, could now be adequately combated by merely dusting the wound with sulfonamide and having the soldier swallow a few tablets of the miracle drug. Subsequent developments, and

time, have demonstrated that these early reports were based more upon hope and enthusiastic impressions than upon facts and sober evaluation. In many respects this was unfortunate, for it led to a shift of emphasis, especially in the minds of surgeons inexperienced in traumatic surgery, from the application of well-established surgical principles to the utilization of a simpler and easier substitute. This occurred despite the fact that the early reports which proclaimed the value of the sulfonamides included the need for applying good surgical principles.[23, 29, 31]

Although the exact status of chemotherapy as regards wound infection has not been completely established, sufficient experience has now accumulated to permit certain observations. There is no good evidence to show that sulfonamides used locally, systemically, or combined can appreciably reduce the incidence or gravity of local wound infection or delay its development. In fact, the best controlled studies of this nature, while not applied to war wounds but to wounds far more favorable for demonstrating the possible beneficial action of sulfonamides, have led to the disappointing conclusion that they exert no important influence in combating local wound infection.[21, 30] Comparable studies on a large scale under a military environment have not been reported, although similar well-controlled observations on war wounds incurred in airmen have been made and the results of these observations show no significant differences between the sulfonamide-treated cases and those in which it was not employed. Summarizing the experience in the North African Theater of Operation, Colonel Churchill[6] stated that "there has been no conclusive evidence presented that the significance of the time-lag (between wounding and surgical treatment) has been altered by the prophylactic administration of sulfonamides in the field, although this program has now been followed with reasonable precision for a full year." Well-controlled studies have been made on the use of chemotherapy, including penicillin, in the secondary closure of soft-part wounds in which the initial operation has been properly performed and it has been conclusively shown that they contribute nothing to the success of this procedure. Although complete evidence is not available, there is some reason to believe that the systemic use of sulfonamides has been of value in controlling invasive infection and preventing death from sepsis.

Penicillin was introduced on the surgical stage at a time when experience was beginning to fade the spotlight on the sulfonamides and direct it again on good surgical principles. This, together with other reasons, permitted its more cautious and rational application in wound surgery and a more sober and intelligent evaluation of its efficacy than was the case with the sulfonamides. Although its precise value in wound management is yet to be completely established, all the evidence points to the fact that as an adjunct its qualities are far superior to those of the sulfonamides. It would seem to be especially useful in the more complicated wounds in which the danger of infection is greater, such as those with bone or joint involvement and those with penetration of the viscera. At present in these cases penicillin therapy is continued after the initial operation and maintained through the period following subse-

quent surgery until the danger of infection is passed. Based upon his extensive investigations on chemotherapy in battle injuries in the Mediterranean Theater, which have contributed immeasurably to the development of this more rational concept of wound management, Major Champ Lyons states: "Local penicillin therapy is used only as a supplement to systemic therapy in the treatment of injuries or infections involving the joints, serous cavities or subarachnoid space. No local therapy has been used in other wounds, reliance being placed on *systemic* penicillin to check or abolish *invasive* infection. Anaerobic wound infection is controlled by the excision of dead cellular protein and the avoidance of primary wound closure. Aerobic wound infection is controlled by preventing wound exudation through the use of splints, pressure dressings and the secondary closure of clean wounds. Contamination of wounds with air-borne wound pathogens is decreased by the abandonment of needless changes of dressing. Repeated local applications of antibacterial agents are incompatible with the efforts to prevent wound exudation and the accumulation of dead plasma protein in the wound." Thus, the use of penicillin as provided by this concept of wound management has made possible the earlier and safe application of the extensive corrective surgery that many of these patients require. The experience so far obtained in the use of penicillin in the surgical management of wounds and wound infection has emphasized both its rôle as a valuable adjunct to surgery and the importance of fundamental surgical principles. It is believed that in this way penicillin has broadened the horizon of surgery.

Perhaps the most serious infection in war wounds is gas gangrene, the occurrence and management of which may be regarded as one index of surgical accomplishment and of the success of other measures in the care of the wounded. In the last war the incidence among our troops was 1.7 per cent. Unfortunately, no precise picture of World War II incidence can be drawn at this time. However, the fragmentary incidence points to the likelihood that the current experience is only slightly more favorable than that of World War I. Until quite recently, and except in selected groups of cases, there has been no evidence of any considerable reduction in the mortality or morbidity attending the infection, the reported experience suggesting a fatality of about 45 per cent in comparison with 47 per cent in World War II.[10] The British experience has been little different, and was aptly expressed by MacLennan who found, on the basis of his observations in the Middle East among British troops, that "neither in prevention nor treatment has much advance been made in the last 25 years" despite the fact that in this period "the potency of antisera has at least been doubled and the whole group of sulfonamide drugs introduced."

Properly executed, prompt initial surgery is still by all odds the most effective prophylactic measure and this factor has always loomed prominent wherever there is recorded an appreciable reduction in incidence, morbidity or mortality. Delay in evacuation and in the institution of surgery or the performance of inadequate surgery has been observed to foster the development

of the infection in wounds received in this war, as in the last war. Although efforts have been made to produce an agent capable of immunizing against the infection, this development has not yet reached the final stage of practical application. Sulfonamides have not proved effective in either the prevention or the treatment of the condition and there is no evidence to show that antitoxin is especially valuable. Penicillin, which offered real promise experimentally, is yet to be thoroughly evaluated. Tentatively, it may be stated that there is little likelihood that it would be effective prophylactically since the infection has occurred in patients who were receiving adequate prophylactic therapy. This has theoretical approval since the drug cannot reach devitalized tissue. On a similar basis, its therapeutic rôle should be in limiting the extension of the infection, a belief which gains support from available clinical experience.

Thus, it may be observed that in the management of wounds and wound infections emphasis has again shifted back to the importance of fundamental surgical principles and the rôle of chemotherapy remains a supplemental one. Here, too, we find a striking parallel with the experience of the last war, during which "early efforts to control the infection of wounds relied mainly on the use of chemical antiseptic application"—and the numbers tried were legion. Only toward the end of that war was it fully appreciated that "the mechanical ablation of the contaminated or infected tissue was the single effective factor." Following a consideration of chemical media employed in wounds at that time it was concluded that the "supporters of antiseptics gained the initial success, but it was by the odd paradox that the success of the antiseptics depended upon the skill with which the surgical means forming a part of the system was perfected and carried out. Even enthusiastic supporters of the antiseptic system discovered that in a wound treated by exposure to the sun, the same mathematical estimate of the length of time necessary for its closure could be made as with the Carrel-Dakin system, and that the period necessary was practically the same in both cases."[19] The almost inherent urge to place some agent, with hopeful healing and anti-infective properties, in a wound seems to lie deep-seated in the human breast and is as difficult to control as the better recognized human impulses. Time and experience have repeatedly demonstrated the inefficacy of such agents. Perhaps some day such an agent will be found but the search seems futile when it is realized that the key to wound infection in traumatic wounds is dead tissue, a fact which Botallo recognized almost four centuries ago, and which Lister fully appreciated.

MAXILLOFACIAL SURGERY

The following statement which was made in the Medical Department, U. S. Army, History of the World War, applies equally well to maxillofacial surgery in the current war: "Very few new principles as regards maxillofacial surgery were developed during the war but the large number of wounds of this character encountered as compared to their frequency in civil life

afforded unprecedented opportunity for demonstrating the advantages and faults of the various operative procedures which had been devised."[20] In fact, as one reads further of the management of maxillofacial wounds in World War I, one is struck with the fact that nearly all the presently recognized fundamental principles were advocated at that time. These are, in brief, the conservation of all viable tissue; the early reduction and fixation of skeletal injuries and the suture of soft-tissue where this is possible without undue tension; the establishment of provisions for adequate drainage and the maintenance of moist pressure dressing; and provision for adequate respiratory airway (by means of tracheotomy if this seems necessary). As experience in this war has accumulated, the importance of these principles has been further emphasized.

NEUROSURGERY

The technic of the management of cranial wounds, as developed by Harvey Cushing in World War I, remains today as the one of choice. However, in the subsequent repair of skull defects which are an inevitable consequence of many of these injuries, a distinct advance has been made in this war with the use of tantalum plate.

With the widespread emphasis placed upon prompt secondary closure of wounds, an earlier opportunity is being afforded for the suture of wounds of major nerves than ever before. In the first months of the war, all cases with nerve injuries were returned to this country for suture, whereas now in many instances nerve suture is being performed in general hospitals abroad with a consequent saving of vitally important recovery time. Experience has proven the value of a sling suture of fine wire between the nerve ends in cases where, during the initial wound revision, it was impossible to accomplish end-to-end suture. This prevents retraction of the cut ends of the nerve and, likewise, permits their easy identification at subsequent operation.

The most approved method of suturing nerves at present is with fine tantalum wire on atraumatic needles followed by wrapping the line of anastomosis with tantalum foil. The latter prevents the nerve from being engulfed in scar tissue and serves as a guide for the down-growing axis cylinders. Until more time has elapsed, a proper evaluation of the results being obtained in nerve suture in this war cannot be made. In an effort to follow these cases for a sufficient period of time to determine the end-result, the Army has issued directives that such cases must report for periodic examinations every three months until the maximum hospital benefit has been accomplished, and has established a Nerve Registry in the Office of The Surgeon-General for all these cases.

THORACIC SURGERY

Owing to the oft-repeated dictum: "Sucking wounds of the chest must be closed at once," attempts were made in the early days of the war to suture such wounds hastily when they were first seen, and often under

conditions which were far from ideal. As a result, many of these wounds broke down, resulting again in a sucking wound which could not be re-sutured due to the surrounding infection. Experience has shown that until the casualty has reached a hospital where adequate facilities exist for careful preoperative preparation and for painstaking surgery, sucking wounds should not be sutured, but should be closed promptly by means of a pad of vaselined gauze molded to fit the opening in the thorax over which a tight adhesive dressing is applied. It is interesting to note that Yates advocated this same procedure in the last war for the same reasons. Another reason for not performing immediate definitive surgery in the case of patients having serious thoracic wounds is that experience has shown they must be brought into a state of equilibrium before they can tolerate major operative procedures. This means that these patients need blood, warmth, rest, freedom from pain and time for readjustment to the changed physiology of respiration if they are to have the best chances of surviving operation.

As the war has progressed, there has been a decided shift to early aspiration of hemothorax in contrast to the feeling in the earlier phases of the war that aspiration should be delayed for several days. The principle of delayed aspiration was based on civilian experience with stab wounds and bullet wounds of the thorax without much soft-tissue or lung damage, and on the theory that the blood in the thorax acted as a deterrent to further bleeding from the lung. In the case of war wounds, in which there was considerable damage to the thorax and in which foreign bodies such as bits of clothing and rib fragments were complicating factors, infection has been found to be frequent. Delayed aspiration, therefore, resulted in many cases of infected hemothorax, in which the entire pleural cavity was involved. It has been discovered that bleeding from the lung does not recur with early aspiration and that the presence of blood in the thorax does not prevent bleeding from the chest wall. The advantages of early aspiration are stated to be that:

1. It relieves high intrapleural pressure.
2. It removes an excellent culture medium for bacterial growth.
3. It aids in early expansion of the lung—a definite advantage in limiting the area of empyema if infection occurs.
4. It decreases the incidence of massive clotting.
5. It prevents the late fixation and contraction of the thorax.

The present procedure of choice is aspiration of all the blood from the thorax within the first 24 hours and daily repeated aspiration if necessary to keep the thorax free of blood. The use of air replacement after aspiration of the thorax which was advocated in the early phases of the war has been abandoned for reasons previously presented.[4] In the light of present experience, the severe criticism of air replacement therapy by members of the American Medical Unit detailed to the study and treatment of thoracic injuries during World War I is of interest.[34]

Probably the greatest advance in thoracic surgery in this war has been

in the management of cases of massive clotting of blood in the pleural cavity and of empyema. Massive clotting of blood in the pleural cavity occurs in about four to six per cent of cases with hemothorax and should be suspected when clinical findings persist after only small amounts of blood can be withdrawn and serial roentgenograms show no improvement during the third to sixth weeks. Using penicillin therapy as an adjunct early operation is done in these cases with removal of clots from the pleural cavity and the dense layer of fibrin from the underlying lung in order to permit rapid expansion of the lung and thus obliterate the cavity. Similarly, in post-traumatic empyema if extensive collapse of the lung occurs early surgical decortication is performed. The application of these surgical principles and this shift of emphasis from local treatment of secondary pleural complications to procurement of early and complete reëxpansion of the lung has provided a significant advance in the management of these serious injuries.

PENETRATING WOUNDS OF THE ABDOMEN

A striking reduction in mortality in cases of penetrating wounds of the abdomen has been accomplished in the present war. In World War I, the mortality among such cases which reached the forward hospitals was 45 per cent, whereas the most accurate figures that can be assembled to date in this war indicate a mortality of 15 to 20 per cent in similar groups of cases. This lowering of mortality is apparently due to three main causes:

(1) Use of ample amounts of whole blood both in the preparation of these cases for operation and during and after the operative procedure.

(2) The availability of larger numbers of well-trained surgeons far forward in the combat areas in installations in which careful surgery can be done and good postoperative care continued.

(3) The widespread use of exteriorization of wounds of the large bowel and of colostomy in the management of these wounds and those of the rectum.

Exteriorization of the damaged segment of bowel through a laterally placed muscle-splitting incision is at present the procedure of choice in the management of wounds of the colon. When exteriorization is not possible, the perforations must be repaired by sutures and a proximal colostomy established. In cases of perforation of the rectum, colostomy is mandatory, and in addition, free posterior drainage of the wounded segment of rectum must be accomplished. This is best established by incision of the fascia propria with exposure of the rectal, sacral, and lateral paramedian spaces.

Two types of colostomy may be performed at the initial operation:

A. *Loop Colostomy:* The bowel is so mobilized that the exteriorized segment will lie on the abdominal wall without tension. No sutures or clamps should be used to fix the bowel in place. This type of colostomy is especially indicated in perforations which do not involve more than one-half of the bowel, and as a proximal sigmoid colostomy in cases of wounds of the rectosigmoid or rectum.

B. *Spur Colostomy:* In the formation of a spur colostomy, the bowel must be mobilized so as to afford free ends at least six inches in length. These are joined by two rows of catgut sutures, preferably placed along the longitudinal fascial bands. This type of colostomy is indicated where perforations are larger than one-half the diameter of the bowel, in injuries which require resection of a portion of the bowel, and in complete transection of the gut.

Colostomy was employed in some of these wounds in World War I, but its use was not considered of the unusual value which is attributed to it today. The following statements from the History of World War I are of interest in this connection: "Colostomy is to be advised in large ragged openings, particularly those occurring in the cecum, descending colon, and sigmoid." "The wounds that are sutured do better than those in which an artificial anus is employed; the latter group gives the high mortality rate of 70 per cent."[13]

The vertical paramedian incision has been found to be the one of choice and the least liable to complications. Closure of celiotomy wounds with rows of buried sutures has been abandoned by many military surgeons of wide experience since it has been considered to contribute to deep infection of the wound. The most widely accepted method of closure consists of the use of a continuous absorbable suture for the peritoneum followed by interrupted stay-sutures of wire or heavy silk. The skin and subcutaneous tissues are not closed, but are separated by a strip of vaselined gauze.

BONE AND JOINT SURGERY

In general, it may be stated that among those surgeons who have had a wide experience with gunshot fractures of the long bones, the trend is distinctly away from "salting" these patients away in plaster encasements and leaving them there until the odor demands a change of the encasement. Under this regimen, the wound will heal in due time, but at the costly price of muscle atrophy, joint fixation, and even skeletal deformity. Efforts to obviate these disadvantages have led to the development of a more active program. At present, the management of a case of gunshot wound of the thigh with fracture of the femur consists of adequate débridement in a forward hospital, secondary closure of the wound in 4 to 12 days in a base hospital, followed by the application of skeletal traction with restoration of length and alignment; maintenance of this traction until the fracture has partially consolidated; application of a plaster encasement for evacuation to the United States, and removal of the encasement on arrival here, with application of suspension traction until firm union permits ambulation with crutches. With this method of treatment, the soft-tissue wound is healed in two weeks, there is little atrophy of important muscles, the joints are kept mobile and union with good length and alignment is achieved. This is in striking contrast with the patients who were received in the hospitals in this country in the earlier days of the war, and had been treated by the "salting down in an encasement

method" and whose wounds were still draining pus, whose bone position was far from ideal, whose joints were stiff, and whose muscles were atrophied.

It has been found advisable to operate upon cases with joint wounds promptly, at which time the joint is opened widely and all loose cartilage, bone and foreign bodies removed. The joint is filled with penicillin solution and the synovial membrane closed, leaving the skin open for subsequent secondary closure. Even if initial operation is delayed for a day or so, this method of treatment is advocated unless there is a fulminant infection present. External skeletal fixation has not proven practicable in combat areas, and its use has been restricted to hospitals in the rear and to those cases with loss of bone substance or with fractures not reducible in the usual fashion.

BURNS

At the beginning of the war, the lack of uniformity of opinion concerning the proper local treatment of burns was evident from the varied types of treatment which were advocated at that time. The most popular of these was the use of tannic acid, while others, such as triple dye films of various materials and even paraffin had their stout supporters. Largely due to the results obtained by its use in the Cocoanut Grove disaster, the pressure dressing applied over fine-mesh vaselined gauze emerged as the method to be adopted by the Army, and the use of tannic acid by Army surgeons in the treatment of burns was forbidden. This pressure dressing method which had been so strongly advocated by Koch has proven eminently satisfactory in the Army. This, together with the fact that the incidence of burns in modern warfare has been less than originally anticipated, has made the problem of burns less significant.

CONCLUSIONS

Finally, it is evident from this brief consideration of approximately three years of combat experience that definite progress has been made in the surgical care of the wounded. This is clearly reflected by the results that have been achieved, for there can be no question that the survival rate among our battle wounded is higher now and the morbidity rate lower than ever before in the history of warfare. While there are undoubtedly many factors that have contributed to this gratifying achievement a critical review of the past three years of combat experience throws into bold relief the one factor that has contributed most—the high standard of surgery being done. At the applied level of practice, this standard of surgery is higher now than ever before, primarily because of the greater availability of formally-trained and well-qualified young surgeons and because of their placement by the organization and plan of medical service, where their skill and talent can be utilized most effectively in the early as well as the subsequent care of the wounded.

It must be acknowledged, however, that while definite progress has been made, it has occurred at the expense of some retardation earlier in the war through repetition of some of the mistakes made and lessons learned in

the last war. To some extent, this may have been due to the fact that the most significant surgical thoughts which emerged from the experience of the last war were just beginning to crystallize when the war ended, with the result that much of their lasting value was lost. The fact, too, that the publication of the last war's medical history was considerably delayed, and did not appear until after all interest in military surgery had waned to the point of cheerfully relegating these tomes to archival desuetude, may have been a contributing factor in this connection. Thus, all the experience of the past three years in the management of war wounds has again affirmed the importance of the fundamental principles of good surgery, principles which became well recognized toward the close of the last war and which critically-minded surgeons have long espoused. At our disposal now are more effective measures of resuscitation and superior agents for the control of infection, but experience has also shown that they must be considered as adjuncts to, not substitutes for, good surgery. They have not lessened the importance of fundamental surgical principles but rather have extended the scope of their application. Combined intelligently, these therapeutic adjuncts and basic surgical principles have led to the development of a more rational and effective program of wound management that has already provided the most gratifying results yet achieved in military surgery and gives promise of far-reaching significance. This development, which has been realized largely through the vision and efforts of our Surgical Consultant in the Mediterranean Theater of Operation and the sound investigations of his staff, constitutes the major advance in the surgery of this war and points the way to further progress.

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REMARKS ON A FEW SURGICAL PROBLEMS IN AVIATION MEDICINE*

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AVIATION MEDICINE is concerned with the medical problems arising from the use of aircraft in flight and, in time of war, those of a surgical nature are greatly increased in number and importance. The character of these problems definitely varies with the hazards involved in the use of the aircraft. That these hazards are increased many fold during wartime flight operations is evident.[1, 2] Because of the large number of injuries in Air Force personnel engaged in training and conflict, special consideration is now being given to the etiology, treatment and prevention of these casualties. It has been learned that unusual and characteristic wounds may be inflicted by accidents associated with flight. This is not surprising when the extreme forces involved are considered; forces that the human body, used to a different pace and environment, is often structurally unsuited to withstand.

For facility of discussion the casualties are grouped according to their causative factor. These factors are *aircraft accidents, enemy gunfire, parachute injuries* and *environment.*

CASUALTIES DUE TO AIRCRAFT ACCIDENTS

Aircraft accidents, viewed casually, seemingly result in such severe trauma that what the physician has to offer, either prophylactically or for curative purposes, appears totally inadequate. A more hopeful outlook is obtained when the situation is reviewed in its separate aspects.

As the speed of flight and landing of aircraft has increased, pilot loss from accidents has increased. Tremendous force may be exerted momentarily while velocity changes are occurring. The rate and method of deceleration determine the distribution of this force in time and space. When exerted on a human being the force may be kept below the minimum consistent with life by a small increase in time—space distribution.

As an example—a plane free-falling, without power, reaches a velocity of ± 120 miles per hour. If the plane strikes the ground vertically so that it is stopped after going into the ground six inches, a pilot weighing 150 pounds will exert a force 484 times the force of gravity, or 140,000 pounds, for the period of deceleration. If the plane plows along the ground for 20 feet before it is stopped, the 150-pound man exerts a force of only 24 times his weight, or 3,600 pounds during the interval. This is compatible with life if distributed over a large body surface.

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Another factor in determining the outcome of an airplane crash is the direction of the applied force. If in the vertical axis, from head to foot, the results may be very different from the deceleration force applied transversely to this axis.

DeHaven[3, 4] has presented factual data derived from persons falling from known heights and terminating their falls by contact with known objects; which indicates that a human being can survive deceleration pressure forces up to 200 times that of gravity, provided it is applied transversely to the long axis of the body and over a large body surface. Much less force can be survived when it is applied parallel to the long axis. The skeletal structures have only a limited space for internal deceleration unless fractured. The internal organs, however, continue in the path of flight after the skeletal structures are arrested. They are eventually stopped by their vascular and ligamentous attachments, but if the force is too great these may be severed, in which case only the confines of the somatic cavity retains them. The path through which the internal organs may move under these circumstances is longer in the longitudinal than in the transverse direction and the potentialities for damage are much greater.

Hass[5] has accurately described the pathology encountered in pilots who have died from forces exerted upon them during airplane accidents. The difference in the rate of deceleration of the skeleton and its contained viscera results in lesions that vary from minor lacerations of one coat of an organ to complete tears of the entire structure. No organ escapes, but the more mobile and bulky are the first to be damaged. The heart, aorta and lungs may be involved with hemorrhage from tears in the auricles, pericardium, pleuropericardial junction, aorta, and parenchyma of lungs. Pulmonary emphysema is common. Lesions below the diaphragm result in wide, gaping lacerations of the liver and spleen, with the latter partially to completely pulled from its pedicle. The small intestine, especially the ileum, may be stripped from its mesentery or actually ruptured.

Clinically, sublethal damage, unless anticipated and recognized, may readily progress to a stage incompatible with life. To be recognized are hemopericardium, cardiac tamponade, pneumothorax, hemopneumothorax, intrapulmonary hemorrhage, diaphragmatic, liver, splenic and intestinal rupture, or mesenteric evulsion of the small intestine,[6] and fractures of all types. Knowledge that such lesions may exist and can be present without evidence of external body trauma will lead to a search for them clinically.

Impact of portions of the body against protruding objects in the plane or on the ground result in puncture wounds, evulsions of tissues, fractures and maxillofacial injuries. The treatment in no wise differs from the care of these conditions caused from any other means.

Hot motors and incendiary missiles contacting spilled gasoline cause frequent fires in plane crashes. These result in burns varying from the superficial flash type to complete incineration. The flash burns are usually of the face and hands, as the remainder of the body surface is covered by the aviator's

clothing. The intense fire from gasoline will quickly consume an unconscious pilot, and in such instances only a charred torso may remain.

CASUALTIES DUE TO ENEMY GUNFIRE

The missiles from enemy gunfire causing casualties in the Army Air Force combat crews are: 20-Mm. cannon shell, machine gun bullets, both 7- and 13-Mm., anti-aircraft cannon shell, rockets and secondary missiles from the plane structures.

The characteristics of these wounds depend upon the conditions under which they are produced. The wall of the airplane must be traversed by the missile before the flyer is struck in the majority of instances. Thus, a bullet which ordinarily would be going forward, end-on, may be caused to tumble in its flight. There is a great difference in the physical aspects of the two wounds.

The "end-on" bullet, traversing soft tissue, produces a clean wound, with a small entrance and exit and a small channel through the tissues. Tumbling (yaw) produces enormous, destructive wounds. The entrance wound is only moderately enlarged but the exit wound is "explosive," and is many times larger than the hole of entrance. The channel is funnel-shaped, with the large opening toward the point of egress of the bullet. The size and character of a wound are dependent upon the amount of energy that the missile producing it expends on the tissues in passing through. Therefore, the increased resistance that is offered to the passage of a bullet turned partially sidewise accounts for the production of the larger wound. If bone is struck by either type of bullet, its shattered fragments will, by the momentum imparted to them, produce secondary damage to the soft tissue.

A shrapnel wound is similar to that produced by a tumbled bullet. Not infrequently, because of its lesser velocity or greater presenting surface, it may not possess enough energy to force it all the way through the tissues. In that case the wound of entrance would be the large end of the cone.

A 20-Mm. cannon generally produces wounds similar to anti-aircraft cannon (shrapnel) but smaller in size, provided the shell has been exploded by contact with the plane structures or body armour. If it is exploded by direct contact with the body, the resulting wound may be enormously destructive.

In general, it may be said that the size and character of a wound imparted by missiles from gunfire depend upon the velocity, mass and presenting surface area of the fragment, and the resistance offered to its passage by the tissues involved.

CASUALTIES DUE TO PARACHUTE INJURIES

Injuries associated with parachute escapes from combat planes are very frequent in contrast to those associated with the parachute jumps of the paratroopers. Approximately 37 per cent of all who are forced to take such a means of emergency exit from an aircraft suffer death or some disability.

A special study by the Medical Safety Division, Office of Flying Safety of the A. A. F., revealed that four emergency parachute jumps were made daily by some Air Force member in the continental U. S. A. and of these, one was injured each day and one killed every other day.[9]

At the present time, one out of every eight emergency parachute jumps ends fatally. Of the escapes which end in fatalities, 48 per cent jumped from

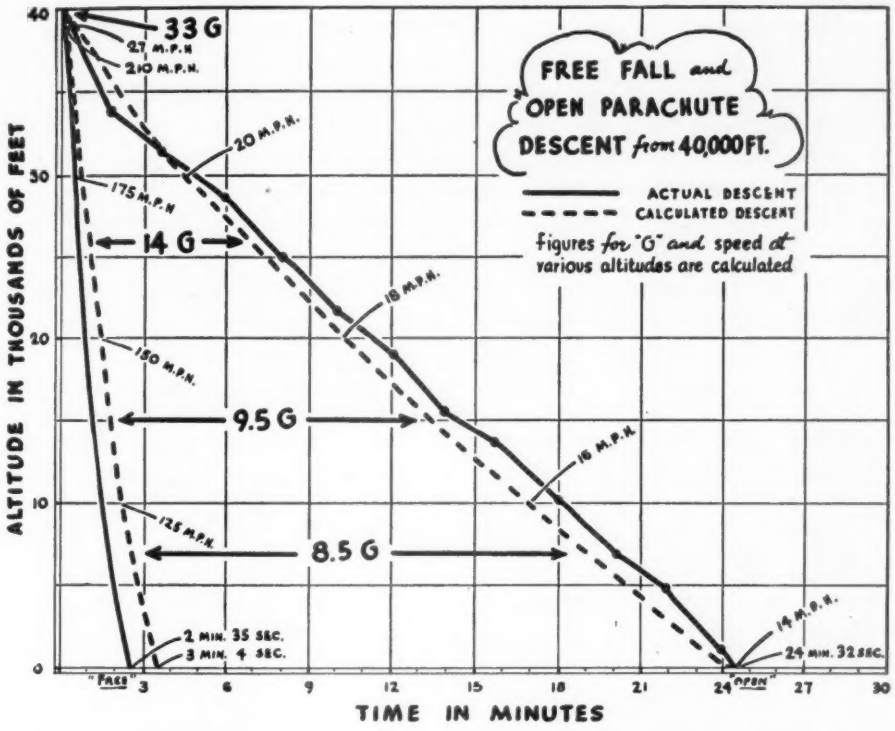

CHART 1.—Diagram showing speeds of free-fall and open parachute descents from 40,000 feet of a 200 pound man.
Note: The force exerted on a free-falling parachutist when his parachute is opened, varies according to the altitude. This force is shown in "G's." which are multiples of the pull of gravity, one "G." being the normal weight of the individual.

too low an altitude, 20 per cent hit the aircraft on bailing out, 10 per cent had their chutes fouled on the aircraft, and 22 per cent were killed from miscellaneous causes.

One out of every four persons who uses a parachute for escape purposes is nonfatally injured. Ninety per cent of the injuries are incurred on landing.

There is a wide variation in the amount of force exerted upon an individual when a parachute is opened during a free-fall at different speeds and altitudes (Chart 1). The variation is also noted between individuals checked by parachutes at the same height due to differences in position, surface exposed, streamlining and weight of the falling mass. Examples will be given to illustrate, using average figures. At 7,000 ft. altitude the force exerted in retarding the fall of a 200-pound man on opening his

"chute" is equivalent to 8.5 times the force of gravity (8.5G.*). This rapidly increases with the higher altitudes, and at 40,000 ft. the force necessary to do the same work is 33 G. Expressed in practical terms, the chute at the moment it is opened must be able to support an applied weight of 33 times 200 pounds, or 6,600 pounds. A body falling free through the atmospheric pressure encountered at this altitude will travel at approximately 210 miles per hour. If the plane is going 400 miles per hour, the necessity for allowing a definite time-lapse to occur between bailing out and the opening of the chute becomes apparent. This will permit deceleration to the free-falling speed. Of course, the lower the altitude the greater will be the difference in rate between the top speed of a plane and the terminal velocity of a free-falling body.

If the chute is opened before the body of the jumper has lost the speed of the plane, the chute may be torn from the shroud lines, at the same time inflicting severe damage on its occupant. One such injury has been known to sever the legs from the flyer's torso. Others of less severity have resulted in fractures of the vertebra, rupture of the diaphragm and rupture of the jejunum.[6]

CASUALTIES DUE TO ENVIRONMENT

Frostbite.—The environment of high altitude flights exposes the aviator to extremes of low atmospheric pressure, low temperatures and low oxygen concentration. The two latter conditions, with the added factor of exposure, result in the clinical manifestations of so-called "high altitude frostbite."

The lowered temperatures, often —50° C. at an altitude of 35,000 ft., result in rapid severe freezing when a part of the body is inadvertently exposed, even for a brief period. The anoxia that a flyer is prone to develop at high altitudes facilitates the freezing. In the early part of the war a large part of all the AAF combat casualties in the European Theater were due to this type of frostbite. This number has been greatly decreased during the past year by studious redesigning of planes, more appropriate clothing, electric heating of gloves and flying suits and education of the flying personnel.

The clinical manifestations depend upon the severity of the freezing that has occurred. Mild frostbite may result in weeks or even months of hypersensitivity to temperature changes. Severe frostbite may result in permanent disability and occasionally loss of an extremity. The toes, fingers, ears, nose, cheeks and forehead are most frequently involved. The relative susceptibility of these parts to frostbite is variable.

Only certain features of the pathologic physiology are definitely understood. An attractive theory, elaborated by Loyal Davis, and his coworkers,[10] would indicate that an initial reflex vasospasm of peripheral arterioles, with resultant ischemia, occurs in the exposed part. Following this, the vasoconstriction at the terminal end of the arteriole may persist for varying lengths of time, up to 24 hours, or longer. Microscopic examination of the capillary bed of the finger tips at this time reveals that the peripheral ends of the

* "G" = the normal weight of the individual.

arterioles are well filled with blood, but that the terminal capillary loops are empty. In instances where the exposure is less severe, the capillary circulation is reëstablished, with damage only to the endothelium. In the prolonged, or extreme, instances of freezing, the arteriocapillary junction becomes obstructed by a thrombus or cellular agglutination, and destruction of the capillary results. Clinically, we may usually differentiate these two degrees of extreme frostbite. In the former, if the vasoconstriction of the arterioles is relieved before obstruction of the lumen takes place and the capillary circulation is reëstablished, extravasation of plasma or whole blood may occur through the damaged capillary wall into the tissues. The fluid accumulates as vesicles or edema, and eventually separates the epidermis and dermis at the germinal layer of cells, with desquamation. If a complete mechanical occlusion has developed within the arterioles at their junction with the capillaries before the vasospasm is relieved, no fluid is lost and the "dry type" of frostbite is obtained.

The same pathologic alterations in physiology occur when the frostbite extends to the tissue below the fascia. Capillary damage results in extravasation and hemorrhage into the muscle, while capillary obliteration by obstruction of the arterioles results in dry gangrene. It is evident that the "wet type" is less likely to result in gangrene and loss of the affected part. Circulatory impairment may persist for months or be permanent, leaving a condition similar to endarteritis obliterans, with hyperplasia of the intima of the arterioles.

Other Conditions.—Other clinical conditions which are influenced in their production by environmental factors are aero-otitis media and aerosinusitis. The mechanism of production, clinical manifestations and various aspects of treatment are problems of more immediate concern to the Otolaryngologist, and, although pertinent, will not be discussed in this communication.

Lightning is a factor which has caused casualties in landed planes improperly grounded, but there is no recorded instance of this occurring in flight.

AIR EVACUATION OF CASUALTIES

The air evacuation of casualties has been one of the major developments in the transportation of the wounded during this War, accomplishing their swift and comfortable delivery to a hospital equipped for definitive surgical care in the briefest possible time.

This subject, in all its ramifications, is one of great importance when we consider that approximately one-half million sick and wounded have been evacuated by air since Pearl Harbor. From June to October, 1944, 55,000 patients were evacuated from France, with the loss of only four-tenths of one per cent of this number after admission to Army General Hospitals in England.

The advantage in logistics alone recommends this mode of evacuation. For instance, fourteen C-54's (large, four-motored cargo planes), each equipped

with 24 litters, can do the job of six 500-bed hospital ships in carrying patients from the Southwest Pacific. Patient travel time is cut from 24 days to 39 hours, the total crew and medical personnel requirements are reduced from 2,136 for the ships to 336, a much smaller holding hospital is required overseas, and the C-54's can also carry military cargo on the outward trip.[11, 12]

TREATMENT

The details of therapy for each condition of a surgical nature encountered in aviation medicine does not belong to the scope of this presentation. General methods, new advances and consideration of therapy peculiar to Air Corps injuries will only be discussed.

In administering first aid, particular care should be exercised if the tourniquet is used. At high altitudes death of a part from circulatory impairment may be much more rapid than at sea level, due to the state of anoxia initially present. The Gallagher[13] pressure dressing is now being used in many combat planes to supplant the tourniquet. When this dressing proves adequate in controlling hemorrhage in a wound containing a severed vessel, there is definitely less likelihood of the loss of the extremity.

Shock is a factor in most traumatic wounds. Extremes in oxygen deprivation and lowered temperatures as found at high altitudes augment the development and continuation of this shock. If not destroyed in combat, mechanical means to overcome both of these have been provided in our bombers. The B. L. B. oxygen mask and the demand oxygen system can deliver 100 per cent oxygen. An electric blanket for protection of wounded from the cold is now standard equipment for the high altitude bombing missions.

The primary closure of wounds has been looked upon with disfavor in this war. This has proven sound policy in the care of injured ground troops when the clothes, missiles and body itself may be grossly contaminated by soil. There are a number of factors that tend to reduce the hazard of infection in wounds produced in the air. As enumerated by McFee,[7] they are:

1. Bomber crews are generally in good physical condition. Fatigue and debility are usually at a minimum as the men have been well housed and well fed.

2. A minimum of contamination is present in wounds produced on a flight. The men's clothes and bodies are clean. The missiles are not soiled and the wounds are free of dirt and other material from the earth.

3. Treatment is generally speedily obtained. First aid, including sulfanilamides and blood plasma are administered in the plane. Definitive surgical care during the "golden period"—four to eight hours after injury—is available on return to the air field. This is compared to the treatment of ground troops who, in many instances may have to wait hours and even days for such care.

These factors give a marked advantage in the treatment of air crew injuries. Because of these it should be possible to decrease the immediate morbidity and mortality, as well as the final disability, since factors that dictate against primary closure of wounds are frequently of less importance in these casualties. Advantage should be taken of this when possible.

It has been found useful to give prophylactic doses of penicillin in severely injured casualties, especially those that are so profoundly shocked that débridement and repair of wounds must be delayed. As an example, a severely shocked crash victim was given 100,000 units of penicillin intravenously along with 1500 cc. of blood and plasma as an initial procedure in treatment. The injured flier had crashed in a swamp and had been pinned under his plane by a tree for about four hours. The large avulsed wounds of his face and arms were filled with swamp water and tree bark. The wounds were débrided and an additional 100,000 units of penicillin were instilled before they were closed. Each 24 hours thereafter he was given an additional 200,000 units for four days. The wounds healed *per primam,* without evidence of infection.

Little new in the treatment of burns has been devised during the present war; however, progress has been made in the standardization and rationalization of such treatment based on our previous knowledge. Never before has there been as universal an acceptance of one method of therapy. As with the majority of good procedures, the regimen accepted is simple, logical and physiologic. Adequate amounts of plasma and whole blood are available for the primary treatment of the burned, shocked patient. Eschar-forming drugs have been almost universally abandoned.[7] In their place have been substituted careful, minimal débridement under aseptic precautions, a bland ointment or petrolatum gauze and a pressure dressing. A method to hasten the separation of necrotic tissue has recently been announced.[8]

There is much controversy about the proper method of treating acute frostbite. In various countries diametrically opposed therapy is often used. Regardless of the methods employed, there are certain principles that should be followed. Every precaution to prevent infection must be taken. The vasoconstriction should be relieved before the capillary is irreparably damaged if possible. Some observers believe this may be accomplished by the immediate blocking of the sympathetic nerves with novocaine. At the same time it is desirable to control the edema and vesication of the affected part, as the circulation can be secondarily retarded by increased interstitial pressures. An adequate means of decreasing the capillary permeability has not been evolved, but moderate pressure dressings, aseptic drainage of accumulated fluid and avoidance of excessive heat or cold aid materially to shorten the wet phase. Oxygen therapy is a logical "must" in the acute stage.

Treatment during the chronic period of frostbite includes late amputation of useless parts, skin grafting physiotherapy similar to that employed in chronic vascular diseases, and temporary or permanent blocking of sympathetic nerves to the involved part.

CONCLUSION

In the future, many lives will be saved by the development of means of preventing casualties from the forces encountered in flying. These de-

velopments will include redesigned interiors of aircraft; improved protective clothing; better methods for overcoming the effects of the conditions imposed by environment; more effective means of controlling fires in aircraft; and stricter discipline, following careful instruction and study of the proper methods of conduct to prevent frostbite, injuries in crash landings, and parachute accidents.

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AN EMERGENCY SURGICAL PLAN IN AN ARMY AIR FORCE HOSPITAL*

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ALL ARMY AIR FORCE HOSPITALS have organized, or are in the process of organizing, an emergency surgical plan by means of which catastrophes may be met and successfully dealt with.

The advantages of a plan of this type are readily apparent. Plane crashes, though infrequent, occur without warning and often involve a considerable number of personnel. These accidents occur frequently at night when many of the surgical staff may be absent from the hospital. The injuries sustained by fliers are usually multiple and often of such severity that the rapidity with which medical aid is obtained determines the outcome to a greater degree than in the majority of accidents originating on the ground. In addition to accidents associated with flying, Air Fields are subject to the hazards inherent in all posts containing a large number of soldiers and motorized equipment. Military posts are also usually located near major railway and highway junctions and, thus, are not infrequently called upon to give emergency treatment to civilians as well as soldiers injured in nearby transportation accidents.

The plan adopted by one Army Air Force hospital to meet surgical emergencies will be outlined. While it is primarily designed to aid in treating injuries arising in military personnel, it would lend itself equally well to the needs of a civilian hospital in the handling of accident cases.

At the beginning, the plan consisted of a notice posted on the Surgical Bulletin Board entitled "Catastrophe Assignments," which reads as follows:

"Catastrophes, involving the injury of a number of persons, occur rarely. Because of the infrequency of such emergencies, considerable confusion may attend the handling of these conditions. In an effort to prevent this, the following outline is prepared:

1. If an emergency of such proportions arises during after duty hours, the Surgical Officer of the Day will be responsible for the notification of the Chief of Surgery, The Chief of Section or Sections involved, The Administrative Officer of the Day, The Anesthetists, Surgical Nurses and Operating Room Corpsmen.

2. The Surgical Officer of the Day will be in charge until the arrival of the Post Surgeon, Chief of Surgery, or Chief of a Surgical Section.

3. The number of Medical Officers summoned will be determined by the Post Surgeon or the Chief of Surgery, or their representative.

4. The telephone numbers of the members of the Surgical Service may be obtained below.

5. The Administrative Officer of the Day and other members of the

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Medical Administrative Corps designated by him will be responsible for maintaining order, checking clothing and valuables and safeguarding public property.

6. The Hospital and/or Post Chaplain must be notified immediately in any major accident or whenever a death may result.

7. In event the services of several Surgical teams are needed, the following tentative assignments are made:

Surgical Clinic Room	*Burn and Shock Room*	*Operating Room No. 1*
(Ambulatory Cases)	Chief of Gen. Surg.,	(Major or minor Surgery)
Ward Officers on	Surg. O. D. and	G. U. and E. E. N. T.
A-5 and A-9	Anesthetist	Staff as needed.
		Corresponding Ward
		Officers

Operating Room No. 2	*Operating Room No. 3*
(Major Surgery)	(Major Surgery)
Chief of General Surgery	Chief of Orthopedics and
Ward Officers on A-11 and A-15	Orthopedic Staff."

For the benefit of those who are not familiar with the term "Surgical Officer of the Day," it should be said that he represents the surgical service during off duty hours when other members of the staff may be absent from the hospital. He is responsible for the care of all surgical hospital patients as well as emergency treatment for those brought to the accident room. This assignment rotates among members of the service and the officer on duty corresponds to a resident in a civilian hospital.

The directions contained in this outline are all simple and self-evident and should occur to the Officer of the Day even if he chanced to be the most junior man on the staff as we should assume he will be in setting up any system. The difficulty lies in the fact that when confronted suddenly with a number of injured persons the surgeon is prone to go from one to another inspecting their wounds in an effort to decide which one needs his attention first and neglects to summon additional aid until valuable time has been lost. If he stops to telephone other members of the staff, he may feel that he is neglecting critically injured persons. On the other hand, if he delegates this notification to a nurse or corpsman, there is a strong possibility that someone will be omitted who should be called. This is especially true of the administrative Officer of the Day, who corresponds to the night superintendent of a civilian hospital and of the chaplain who should always be notifed in any major accident.

A check list of this type would remind the surgeon, or any one he might delegate to handle it, of all persons who should be called. The operating room assignments would also serve as a tentative guide but could be altered readily depending upon circumstances.

After this plan had been in operation a short time the thought occurred that surgical catastrophes were not confined to mass injuries, but that a single emergency inadequately, or improperly treated, or a preventable death

occurring in the operating room, constituted a surgical catastrophe just as truly as a plane crash. The difference is a quantitative, rather than a qualitative one. In view of this, the plan was enlarged to include all of the more common emergency conditions that might arise on the wards, in the operating rooms, or on the post.

All equipment that might be needed in the treatment of emergencies was placed in one room in the surgical pavilion. This room was chosen due to its proximity to the operating rooms and the surgical wards. Each

FIG. 1.—View of shock and emergency surgery room. This room is situated close to the operating room, the surgical wards, and the emergency room for the treatment of out-patients.

surgical specialty was requested to prepare packs permitting immediate treatment of emergency conditions arising in that specialty.

Three surgical carts were stocked with medications, sterile instruments and dressings. One cart contained plasma, sterile water, vaselined gauze, machinist waste, sterile dressings, stockinette, wooden splints, mineral oil and other supplies needed in the treatment of burns. A second cart contained sterile packs permitting immediate tracheotomy, thoracotomy, craniotomy, and repair of vascular and nerve injuries. Intravenous and transfusion sets as well as sterile gowns, gloves and linen were included in this set-up. It was not anticipated that major procedures would be carried out in the emergency surgery room or by junior members of the staff, but it was felt desirable to have all equipment of this type in a central location familiar to every member of the surgical staff. A third cart was stocked with dressings and instruments needed in the repair of the more common injuries involving the soft parts.

FIG. 2.—View showing one side of emergency room. The dressing cart on the left contains equipment to be used for the treatment of burns. The cart on the right contains sterile packs. The contents of each is clearly noted on outside labels. These packs will permit emergency procedures to be carried out with a minimum of delay. Thoracotomy sets, tracheotomy sets, arterial suture instruments, and various other sterile equipment are included in container.

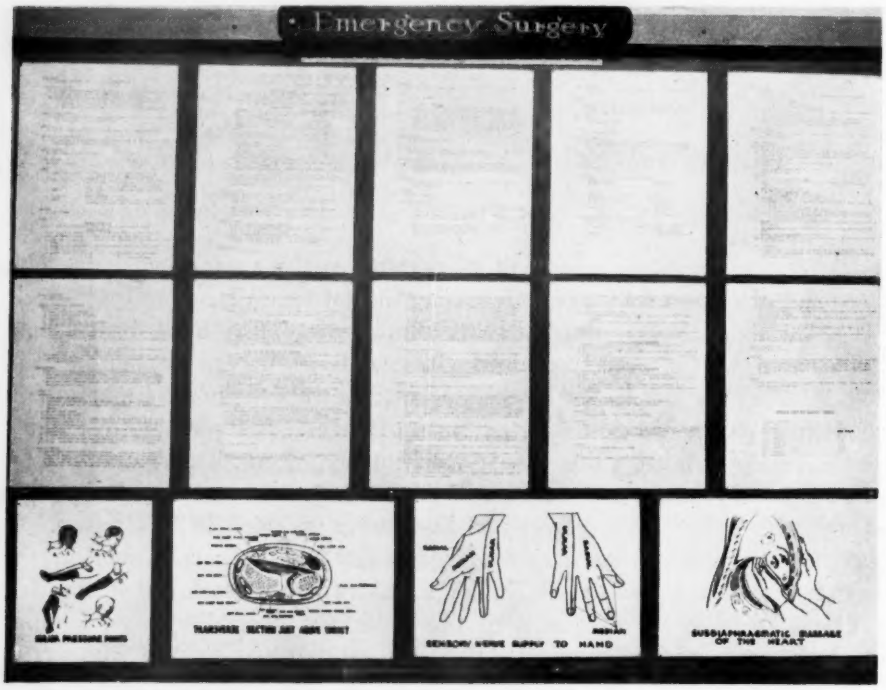

FIG. 3.—View showing Emergency Surgery Bulletin Board with outline of first aid treatment, tests recommended in certain conditions, and operative aids to guide surgeon in special procedures. For example of conditions listed on first sheet of this outline, (see text.)

An important feature of these sets is the conspicuous labelling of all instruments and supplies contained in the packs. This conserves both time and sterility by preventing the opening and contaminating of packs containing unwanted material. Additional equipment of an emergency nature is contained in this room. A resuscitator and oxygen tanks are available in case of drowning or illuminating gas poisoning. A drug box is at hand which contains all of the more common emergency medications. Each ampoule is held in a designated space and when the box is opened the name, dose and indication for use of the medication appears on the under surface of the lid immediately above the drug described. Alcohol sponges with sterile syringes and needles are also contained in the drug box to prevent loss of time. Every effort has been made to leave as little to chance and memory as possible. Frequent inspections are made to insure that supplies are replenished promptly after use.

Probably the most important feature of the emergency room is a large bulletin board which contains in alphabetic order the recommended treatment for all anticipated surgical emergencies. Some of the procedures are not strictly emergency aids but rather reminders of tests which should be carried out before a patient is released, operated upon or admitted to the ward. While this system is designed primarily for the guidance of the younger men on the service it also contains data which may not be readily recalled by the older members of the staff when urgently needed. The antidotes for various poisons are listed and the insect and snake bites for which there are specific antivenoms are included.

This outline is not intended to encourage recent graduates to carry out procedures with which they are not familiar but rather to prevent them from overlooking commonplace measures which might be forgotten in the haste of the moment. Conspicuously displayed at the top of the bulletin board is a notice to the effect that the surgeon on call should be notified in all cases of severe injury or when a major operative procedure may become necessary.

This guide also serves another purpose. The technic of some of the more involved but infrequent surgical procedures are outlined, for example the method of handling cardiac tamponade by aspiration and the indications and operative approach for pericardiotomy. The recommended treatment for wounds involving major vessels and nerves and safeguards in handling injuries to the hand are included. Should the occasion arise, this would enable the surgeon operating to direct an assistant to leave the operating room, step across the hall and read in a moment the indications, technic and possible contraindications of a debatable procedure. It might be added that this aid has not been necessary since the plan was adopted, but the best guarantee against such a need arising lies in having the data readily available. The speaker can recall instances where he would have welcomed such a guide in handling unexpected surgical problems.

An example of the data contained on one sheet of this outline is as follows:

"*ALCOHOLISM:* 1. Symptomatic, draw blood for alcohol determination.

FIG. 4.—Drug and dressing cabinet showing the labelling of each item in order that these materials may be obtained without delay when needed. Note the resuscitator and emergency drug box.

ANAPHYLACTIC SHOCK: 1. Prophylaxis—intradermal test always before injection of serums (A. T. S. and perfringens) and desensitize when indicated.

2. Treatment—in addition to measures listed in traumatic shock, (See shock) give:

A. Epinephrine—0.5 to 1.0 cc. of 1:1000 solution subcutaneously or 0.5 cc. intravenously. Repeat in few minutes if necessary.

B. Atropine—0.001 (1/60 gr.) subcutaneously has been recommended.

APPENDICITIS, ACUTE: 1. History, physical, rectal examination, complete blood count, urinalysis with microscopic. Call surgeon on call.

ASPHYXIA: 1. Artificial respiration, resuscitator, oxygen. (See cardiac arrest).

ASPIRATION OF PERICARDIUM: 1. This should be done with a 17- or 18-gauge needle by costoxyphoid route. (See Cardiac Tamponade, treatment of).

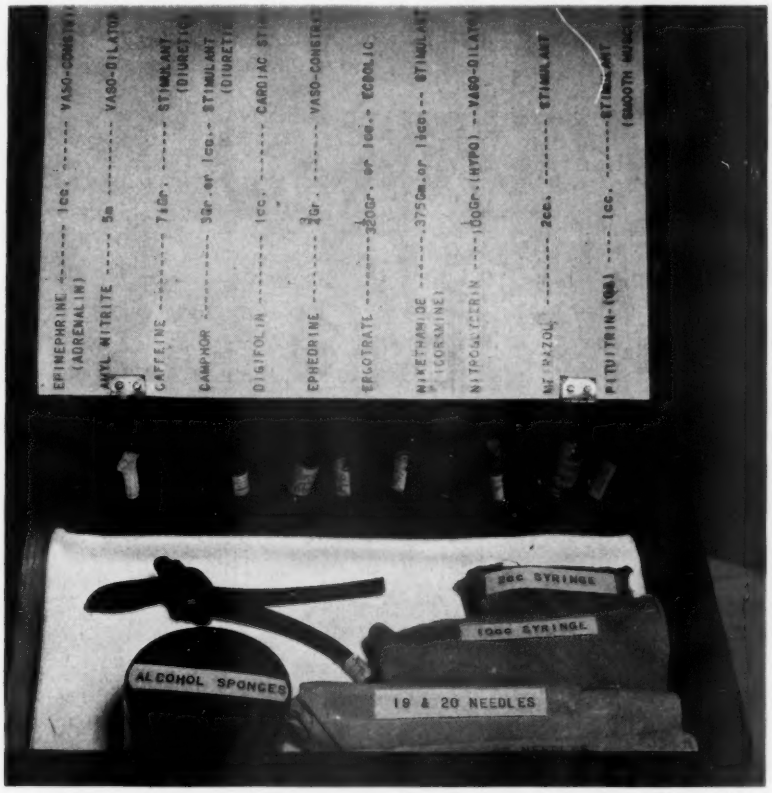

FIG. 5.—Drug box containing emergency drugs, needles, and sponges. The top of the box has the name, dose, and action of each drug, which is placed in an appropriate space beneath.

BERKOWS TABLE: 1. (See Burns, general treatment of).

BLOOD VESSELS: 1. (See Wounds of).

BITES: 1. Black Widow spider: Sedatives, calcium gluconate, normal saline I. V., sodium pentothal I. V. if necessary.

2. Dog: Identify and observe dog. If simple bite, treat as laceration. If large—débride; tetanus toxoid if indicated. (See tetanus).

3. Human: Débridement; sulfa generally; leave wound open.

4. Scorpion: Treat symptomatically.

5. Snake: Identify snake if possible. Tourniquet, incise, suction, antivenom for rattlesnake, moccasin and copperhead. Treat symptomatically.

BLADDER: 1. (See Wounds of).

Initial Treatment

BURNS: 1.65 per cent of all deaths in burns are due to shock—*Avoid shock.*

Local Treatment

Place patient on sterile sheet. Surgeon must wear cap, mask, sterile gown and sterile gloves. Everyone in burn room must wear masks.

1. Débridement, consisting of opening large blisters and trimming loose skin.

2. Remove gross contamination by sterile water, white soap and cotton pledgets, use abundance of water.

3. Remove grease with sterile mineral oil followed by soap and water.

Several sketches beneath the typewritten matter depict: pressure points in the control of hemorrhage; the structures that pass through the wrist; the sensory nerve distribution to the hand; and a method of cardiac massage. These drawings were included because occasions have arisen when this data would have been of value.

In conclusion, it is desired that the following points be made clear:

1. No claim for originality is made for the foregoing plan. Many hospitals, no doubt, have devised various plans designed to meet surgical emergencies. It is felt, however, that this system is a practical one and every effort has been made to make it as foolproof as possible.

2. Although this plan was designed to meet the needs of a military hospital, it should lend itself equally well for use in civilian hospitals.

3. The objection may be raised that the time and trouble necessary to organize and keep in readiness a plan of this type is not warranted by the occasional patient in which it might be of value. This hardly is a valid criticism, for if such a system resulted in the saving of one life over a period of many years, its adoption would be justified.

DISCUSSION.—DR. LOYAL DAVIS, Chicago, Ill.: There are two comments I would like to make upon Col. Shands' very interesting paper. One concerns high altitude frostbite; and the other injuries received by airmen from Oerlikon shells. In our studies of high altitude frostbite it was found that the majority of cases were waist gunners who were subjected to the direct blast of cold air in temperatures often as low as —52 degrees, without the protection of plexiglass which gunners in other positions were afforded. It is my understanding that this has now been remedied, with a very definite decrease in the number of casualties.

Early in the history of the 8th Air Force in England, high altitude frostbite constituted one of the largest groups of casualties. The oxygen bags became frozen because the masks were not of the demand type and because the tube leading into the bag was so small that saliva collected and froze. This necessitated the removal of the mask and putting on the auxiliary mask. Unfortunately, the method of fastening the mask onto the leather helmet consisted of fasteners which could not be grasped when flying gloves were worn; therefore, the airmen took off the gloves to fasten the mask in place. Since the electrically heated suits and gloves were wired in series instead of parallel, the removal of even one glove threw the heat off for the entire suit. At the altitude at which these men worked, it required only a few seconds for the most serious case of frostbite to occur.

Attention was also called to many problems in the education of airmen, such as the fact that there is a relative anoxemia at an altitude of 10,000 feet; the proper care of

electrically heated clothing; wearing gloves which did not fit properly, and the tendency to trade clothing. All were factors in producing the high casualty rate for this condition. I am glad to learn, even though it was belated, and had not been anticipated, that steps have been taken to correct these technical and engineering difficulties. High altitude frostbite can be prevented and it is extremely important to prevent it, because once the lesion has occurred in severe form, there is either a loss of tissue or impairmant of function which is permanent.

Many of the injuries from fragmenting Oerlikon shells are also preventable by the use of properly constructed protective flying clothing. A plastic helmet was proposed which would closely simulate the ordinary leather flying helmet and which would offer one-third more protection per unit weight than 1 mg. manganese steel, and had very little weight. Other advantages of such a plastic helmet were pointed out and it was suggested that sheaths of similar plastic material could be inserted into the flying suits and provide protection for other parts of the body which would be adequate. The important advantage was, of course, that such protection did not weigh from 16 to 25 pounds, and would not constitute such a mental and physical handicap that the flyer would prefer not to wear the protection. This was presented for consideration to the Army Air Corps and the Quartermaster Corps, and it was also pointed out that it could be made applicable to the armored forces. I am glad to learn that the United States Navy and Marine Corps have adopted the principle of plastic protective clothing, and in field tests have proved its practicability. Perhaps, it still may not be too late to receive consideration for the use of army flyers and tank crews. This announcement has just been made in the Bumed News Letter of the United States Navy, November 24, 1944.

Col. F. S. Gillespie (B. M. C.), Carlisle Barracks, Pa.: I am glad to have the opportunity of telling you something of the work of your Medical Corps, which I was lucky enough to see in Normandy in July. I was greatly impressed by the speed of evacuation, and this was largely due to the efficiency of the forward medical personnel, the litter bearers and the drivers of jeeps which picked up their casualties right forward of Battalion Aid Posts. Wounded men were frequently picked up within a few minutes of being wounded. I do not think that nearly enough credit is given to these men for their gallant work. We are inclined to pat ourselves on the back for our wonderful hospitals, our wonderful surgery and our wonderful drugs, but none of these would have such good scope were it not for the splendid work of these corpsmen who get the patients rapidly back to where the other things are available.

Patients were speedily taken through the Battalion Aid Post, Collecting Company and Clearing Companies in the Divisional Area, in many cases on jeeps with improvised racks for litters and a Red Cross flag; these vehicles working in forward areas were respected by the Germans.

The most important life-saving surgery was being done by the platoons of Field Hospitals, working alongside Clearing Companies of the Divisional Medical Battalion; these units were reinforced by Surgical Teams and Shock Teams from the Auxiliary Surgical Group—and the combination was a most successful one. I saw some members of the same Auxiliary Surgical Group after the fighting in North Africa last year, and they were somewhat disgruntled because they felt they had not been given the opportunity of getting the forward surgery they had hoped for. They were rather looked on as "blackleg labor" trying to pinch the work from needy surgeons at Evacuation Hospitals and Clearing Companies. They were commanded by Colonel Blatt, and were affectionately (?) known as "Blatt's Bastards." They mentioned their grievance to me in Tunis and I said to them: "Wait a bit, when casualties start occurring in large numbers they will be damned glad to get you"—and so it was.

Transfusion facilities with plasma were available at Battalion Aid Posts and Collecting Companies, and transfusion with whole blood was available at the Field Hospital Platoons. There, too, there had been a great improvement; in North Africa last year faith had chiefly been pinned to plasma but now there was a swing over to the use of whole blood, and surgeons were constantly demanding it for the severely wounded treated at Field Hospitals. When it was in short supply, there was a brisk reverse "lease-lend" process going on, with blood from British transfusion units, in fact a great many American soldiers were much improved by having good British blood in their veins. I know they received temporary benefit; let's hope it will be permanent.

The Surgical Teams were doing excellent work, and relays of them were working 24 hours a day. I do not think many lives were lost which could possibly have been saved. The statistics of results obtained are little short of amazing, but in this connection I should like to warn you against the tendency to use statistics like a drunkard uses a lamp post—more for support than illumination. I think you, over here, can rest assured that the rapid evacuation and early efficient surgical attention combined with adequate transfusion facilities with whole blood, now being made available from this country, are combining to give the wounded man a better chance of survival than has been possible previously.

DR. J. E. J. KING, New York, N. Y.: I should like to ask Colonel DeBakey whether he has any definite information on the intrathecal use of penicillin or sulfanilamide in early cases of perforating lesions of the skull where the ventricle is involved; and a second question on the use of these drugs with late cases of infection of the brain.

DR. FRANK K. BOLAND, Atlanta, Ga.: As one of the facilities on the battle front which impressed him, Colonel Gillespie referred to transportation of the wounded to First Aid Stations and Evacuation Hospitals. It does not seem out of order, in this connection, to give credit to the man and agency which first inaugurated organized, adequate transportation, which has been developed to such a high degree of efficiency in the present war, especially by the Medical Department of our own Army.

During one of the wars in Central Europe, in 1863, Henri Dunant, a Swiss gentleman of means, was horrified by the neglect of wounded soldiers which he witnessed while visiting an area where a battle had been fought recently. Little attention seemed to be paid to the sufferers lying all around, and he called for volunteer stretcher bearers, and soon was carrying the wounded men to places where they could receive medical and surgical attention. This is said to be the first time such a systematic project was carried out. Thus, was born an organization destined to become the great Red Cross Society. So, as we praise the Red Cross for its marvelous contributions to the care and comfort of our fighting forces, let's not forget that it was this agency, through philanthropic Henri Dunant, that first taught armies modern transportation of the wounded, without which many triumphs of modern military surgery could not be utilized.

DR. I. A. BIGGER, Richmond, Va.: I would like to stress one or two points in connection with Colonel Warthen's paper. It is evident that military surgeons have somewhat belatedly recognized the importance of the early treatment of wounds by well-trained surgeons, but in some civilian hospitals the emergency care of patients who have been severely injured is still entrusted to relatively untrained members of the staff. Some of the reasons for this are legitimate, but I would like to emphasize the importance of having the hospital staff so organized that when seriously injured persons are admitted, senior as well as junior members of the staff are promptly notified. Colonel Warthen has described the manner in which this is accomplished in certain Air Force Hospitals. A similar plan could be used to advantage in civilian hospitals.

LT. COL. A. R. SHANDS, JR., Washington, D. C. (closing): I want to thank Dr. Loyal Davis for his remarks on high altitude frostbite; no one in this country has had more experience with this condition than he has had. These injuries are preventable, as has been stated, and, certainly, the decrease in their incidence proves this point. It is principally a question of having improved flying suits and better protective equipment. Doctor Davis has asked about body and head armor; this certainly decreases the incidence of casualties. The missiles of low velocity definitely inflict less serious wounds than those of high velocity.

In conclusion, a word should be said about air evacuation. It is one of the great accomplishments in the transportation of the wounded in this war. More than half a million patients have been evacuated by air since the beginning of the war, and 55,000 from France alone since D-day.

LT. COL. MICHAEL E. DEBAKEY, Washington, D. C. (closing): In reply to Doctor King's question, penicillin has been used intrathecally in the type of cases to which he referred, and the results are considered encouraging, although I am not in a position to give the actual figures.

AN ANALYSIS OF THE RESULTS OF THE SURGICAL TREATMENT OF 260 CONSECUTIVE CASES OF CHRONIC PEPTIC ULCER OF THE DUODENUM*

WILLIAM FRANCIS RIENHOFF, JR., M.D.

BALTIMORE, MD.

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IN 1939, I made a report upon the surgical treatment of 82 consecutive cases of peptic ulcer of the duodenum in the Johns Hopkins Hospital before the meeting of the American Surgical Association; at that time an operative technic was described which was based on certain anatomic and physiologic considerations that combined safety and efficacy, in a higher degree than the more conservative and also the more radical procedures. This operative procedure, however, like others carried out in the past, has limitations as a treatment for peptic ulcer of the duodenum; the determination of the type and extent of resection of the stomach and duodenum most acceptable from the standpoint of immediate and remote results will be ascertained only by comparison of reports of series of cases operated upon by different methods. The 260 patients herein reported have been operated upon by the same technic with the exceptions noted in which further resection became necessary because of postoperative complications. Thus the operative technic has been as nearly constant as possible.

Because of the fact that the series is composed of private patients, follow-up examinations could be carried out from time to time for a period of two to ten years by the physicians referring the patients for surgical treatment. Apparently a unique feature of this study has been the frequency of direct or indirect contact with the patients as well as their physicians. Every six months information has been obtained either personally or by letter from patients and often, as well, from their physicians. Thus, there have been no long periods of time during which a patient has been lost track of, nor a single instance in which a patient has failed to report. In this respect, postoperative studies are more easily carried out on private patients than on patients on the public wards. Because of this continuing follow-up, I came to know intimately a high percentage of the patients which enabled me to interpret more accurately the reports from both the patients and their examiners. In each case there had been commendable cooperation on the part of the patient in an attempt to obtain permanent relief of symptoms by faithful adherence to a medical regimen for periods ranging from 4 to 20 years previous to operation. Patients who for various reasons had not been conscientious in this respect were not included in the series. This series might, therefore, be classified as a specially selected group of patients who were subjected to surgical treatment because the complications of chronic peptic ulcer of the duodenum were not amenable to medical therapy.

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The rationale of the operative technic was as follows: (1) The most active portion of the stomach from the standpoint of contractility, namely, the pylorus, the pyloric antrum and the fundus as far cephalward as the incisura angularis have been removed. By this procedure the acid-stimulating portion of the gastric mucosa lining the pyloric antrum was removed as well as one-third to one-half of the acid-secreting mucosa of the fundus. The removal of the mucosa of the pyloric antrum, therefore, takes away the major factors in the stimulation of gastric juice—acid and pepsin—by preventing the formation of the gastric hormone—gastrin. (2) Re-establishment of the continuity of the gastro-intestinal tract has been accomplished by the use of an antecolic gastrojejunostomy. The larger stoma created by this operative procedure brings about prompt emptying of the remaining pouch of stomach, thus, preventing the "pooling" of gastric juice and the retention of food products in the gastric pouch, which act as a constant source of stimulation for the secretion of digestive juice. (3) The Pólya-type of anastomosis permits free irrigation of the remaining pouch of stomach with the alkaline duodenal secretions, bile, and pancreatic ferments, and, therefore, produces a maximum degree of neutralization of the gastric contents. In this type of anastomosis following resection of the stomach, all of the duodenal contents *must* enter the portion of stomach remaining, which is not the case following other types of operations such as the Finsterer, Hofmeister, or Billroth II. (4) The flow of gastric contents is diverted from the ulcer-bearing portion of the duodenum into the jejunum. (5) A conservative resection followed by an antecolic gastrojejunostomy has a lower immediate mortality, and in the event of postoperative complications necessitating a further surgical procedure the technical difficulties of more radical resection are far less than those experienced when a retrocolic type of anastomosis has been employed with a primary resection (three-fourths to four-fifths) of the stomach. The necessity for performing radical resection routinely for peptic ulcer of the duodenum is not apparent when all but a relatively small percentage of these cases are satisfactorily treated by conservative resections with a lower immediate mortality.

Clinical Material.—The number of patients forming the basis of this report totals 260, of whom (Table I) 83 per cent were males and 17 per cent females, a ratio of approximately 8 to 1. The distribution of these patients as to age was interesting, revealing the fact that 31 per cent were below and 69 per cent above 40 years of age. The majority of cases occurred in the fourth decade. Particularly in the male this period of life would probably represent the decade of greatest mental stress and strain due to business or professional worries or vocational hazards.

Symptoms.—Each of the 260 patients in this series was referred for surgical treatment because of complications which developed as a result of the presence of a chronic peptic ulcer of the duodenum. Acute perforating ulcerations are not included in this report because it is felt that the surgical

problems presented by such cases differ from those of nonperforating duodenal ulcers. The complicating clinical features which were responsible for the discontinuance of medical treatment and the shift to surgery were mainly intractable pain, hemorrhage, and vomiting. In Table II an attempt has been made to group these patients according to the preponderance of the

TABLE I

AGE AND SEX RATIO IN 260 CASES

SEX RATIO

Sex	No. of Cases	Percentage
Male	216	83%
Female	44	17%
Total	260	100%

AGE GROUP

Age	No. of Cases	Percentage
Less than 20	2	1%
20 to 30	21	8%
30 to 40	57	22%
40 to 50	99	38%
50 to 60	55	21%
60 to 70	24	9%
Over 70	2	1%
Total	260	100%

different symptoms or signs. It is to be emphasized that the clinical course of a patient is often difficult to evaluate because not infrequently excruciating pain associated with penetrating ulcer of the anterior wall will so absorb the patient's attention that considerable amounts of blood in the stool will be overlooked or will be noticed only by a member of the family or the attending physician. Thus in Table II it is seen that 93 per cent of the patients had pain, but there was also bleeding and vomiting. In only 2 per cent was there vomiting alone, but in 49 per cent vomiting was associated

TABLE II

SYMPTOMS

93%, or 242 cases	Pain		
	Pain without bleeding	56% of 260, or	146 cases
	Pain with bleeding (below)		
42%, or 109 cases	Hemorrhage		
	Bleeding with pain	37% of 260, or	96 cases
	Bleeding without pain	5% of 260, or	13 cases
49%, or 127 cases	Vomiting		
	Vomiting alone	2% of 260, or	5 cases
		100%	260

with pain and bleeding. In only 5 per cent was bleeding present without a history of pain, and in each of these patients, the hemorrhages were very severe; yet 37 per cent of the 260, or 96 cases, not only suffered from bleeding but also had pain of a greater or lesser degree of severity. In the 42 per cent in whom bleeding occurred there was found at operation an ulcer in the posterior medial wall of the duodenum which had penetrated into the head of the pancreas; in every instance there was an associated chronic pancreatitis. The severity of the bleeding depended entirely on the

size of the pancreatic vessel which had been eroded—whether the pancreaticoduodenal artery itself or one of its larger branches. In every case in which one can obtain a history of bleeding the presence of a penetrating ulcer of the posterior wall of the duodenum can be confidently predicted.

One of the most striking pathologic observations in this series was the high percentage, 75 per cent, of the instances of multiple ulcerations of the duodenum. Scars of healed ulcers on the anterior and superior surfaces of the duodenum were often associated with ulcers of the posterior wall. In many instances the duodenum was actually a ligneous tube. When one considers the fact that the symptoms and signs of which these patients complained over a period of many years were constantly changing from season to season, from pain to bleeding to vomiting, it is not to be wondered that ulcerations would have occurred in different regions of the duodenum. It appears conceivable that even though an ulcer of the anterior wall producing severe pain were to heal, the persisting disturbed physiologic mechanisms of the stomach should at a later date produce an ulcer of the posterior wall that would cause bleeding. The clinical history of the majority of the patients in this series suggests this sequence of events. Pain in the back probably due to involvement of the head of the pancreas was frequently associated with ulcers of the posterior wall. Specimens of the stomach in every instance showed infiltration of the submucosa with small lymphocytic cells, which has been interpreted as evidence of chronic gastritis. In some instances anamnesis reported a simultaneous occurrence of these complications, and again their appearance was sequential, so that division of these patients into definite groups under the heading of symptoms of pain or hemorrhage or vomiting would, with minor exceptions, be inaccurate and misleading. Practically all of the patients at one time or another, or at the same time, suffered from all the complications.

The chronicity and the recurring nature of these complications, with the necessary living restrictions which they imposed, had much to do with the decision of these patients to switch from a faithfully observed but unsuccessful medical regimen to surgery. Except in the few instances of exsanguinating hemorrhage, the inability to lead a normal life, due to constant pain, nausea, vomiting, indigestion, and the apprehension of repeated hemorrhages, rather than some catastrophic clinical incident such as perforation, almost fatal hemorrhage, or complete obstruction of the pylorus, led the patient to seek such relief from surgery. In this respect private patients may well differ from those of the dispensary or the public ward. The former, becoming intolerant of relative incapacitation at an earlier stage, and having a more intelligent attitude towards surgical procedures, would be inclined to seek such relief before complications had assumed ominous proportions. Therefore, emergency operations for acute perforation or occasional massive hemorrhage should be considered separately from the elective surgery of the chronic duodenal ulcer. Undoubtedly, the problems

of both medical and surgical therapy presented by patients of different economic status vary to a large extent.

Immediate Results.—The immediate postoperative mortality in the 260 cases was 2 per cent, or five deaths. There have been no deaths in the last 160 cases. The cause of death of the five patients dying in the hospital was (1) shock following massive hemorrhage, which was observed too long before operation was performed; (2) sloughing of the duodenum, which had been mobilized too far down from the head of the pancreas for ulcer in the region of the ampulla of Vater; (3) transfusion reaction; (4) postoperative hemorrhage five weeks after the patient had been transferred to the medical service. The cause was unknown as autopsy was not performed. Since there was a loss of consciousness a cerebral hemorrhage may have ensued; and (5) bronchopneumonia. In only one death could the surgical technic be held responsible and that was the case in which the duodenum was dissected too far down from the head of the pancreas. This is the only instance in the entire series in which the duodenum has leaked. As a result of this experience, extensive mobilization of the duodenum has been abandoned, for regardless of whether the ulcer is excised or not, the attendant isolation due to closure of the duodenal stump will result in its healing *in situ*. In the exceptional case of massive hemorrhage with exsanguination, the duodenum has merely to be opened and the ulcer transfixed with a suture. The condition of the patient as a rule prohibits any more extensive surgical procedure, such as resection, at that time.

It would seem reasonable, therefore, to expect that in the future the immediate operative mortality in a similar group of patients might well be reduced even further. Even now, an operative mortality of 2 per cent provides a margin of safety as great as that of the most conservative operations for chronic peptic duodenal ulcer.

Remote Results.—Until the cause of chronic peptic ulcer of the duodenum is known the surgical treatment of its complications must remain empirical. The primary objective of operative procedures in these cases is to protect the patient against complications such as hemorrhage, jejunal or marginal ulcer, pain and pyloric obstruction. The secondary objective is to prevent a recurrence of the same complications that followed the original duodenal ulcer. Regardless of the type of operation performed or the operator, where jejunal and gastric mucosa are brought together in the presence of acid chyme a certain percentage of patients will suffer from postoperative complications similar in all respects to the original complications of the primary ulcer for which operation was performed. In this follow-up study which has covered periods of 2 to 10 years in which either direct or indirect contact with the patient has been maintained every six months to a year, the classification of well, improved, and unimproved has been employed. Most postoperative complications manifested themselves in the first two years, but even to the tenth year patients have had to be shifted from the well to the improved column due to a late return of symptoms.

Table III presents an outline of the results as accurately as could be determined. It is to be noted that this study shows that of the 204 patients, or 78 per cent now considered well, only 172, or 85 per cent, have so far had no complications since operation. Thirty-two patients, or 15 per cent of the 204 known to be well, have had postoperative complications. It was necessary to operate again upon 22 of these, but they are at present well and completely free of signs or symptoms of peptic ulcer.

TABLE III

RESULTS ON 260 STOMACH OPERATIONS

Well	204 cases, or 78%	
	Without complications	172 cases, 85%
	With complications	32 cases, 15%
	Reoperated 68% (22 cases) of above 32	
	Complications:	
	Pain	12 cases, 6% of 204
	Hemorrhage	12 cases, 6% of 204
	Marginal or jejunal ulcer	12 cases, 6% of 204
	Above with perforation	4 cases, 2% of 204
	Adhesions	4 cases, 2% of 204
	Average free acid (postoperatively) 13	
Improved	30 cases, or 12%	
	Reoperated 16%, or 4 cases of above 30	
	Complications:	
	Pain	22 cases, 77% of 30
	Hemorrhage	5 cases, 17% of 30
	Marginal or jejunal ulcer	1 case, 3% of 30
	Adhesions	2 cases, 6% of 30
	Recurrent duodenal ulcer	1 case, 3% of 30
	Average free acid (postoperatively) 36	
Unimproved	21 cases, or 8%	
	Reoperated 15%, or 3 cases of above 21	
	Complications:	
	Pain	8 cases, 38% of 21
	Hemorrhage	9 cases, 46% of 21
	Marginal or jejunal ulcer	10 cases, 54% of 21
	Recurrent duodenal ulcer	1 case, 7% of 21
	Average free acid (postoperatively) 53	
Mortality	5 cases, or 2%	
Total	260 cases, 100%	

The average degree of free acid in this well group was low as compared to the improved and unimproved groups. Obtaining accurate figures for gastric analysis offered a difficult problem because of the different technics employed for obtaining this information. Some physicians preferred to base their estimate on the acid determination in the fasting stomach, others on the Ewald test meal, and still others on the alcohol and histamine method.

TABLE IV

ANACIDITY

40% (107 cases) of 260 had no free acid after operation.
8% (9 cases) of above 107 developed postoperative complications, such as marginal ulcer or hemorrhage.
92% (98 cases) of above 107 remained well.

It appears that the two first methods give a better insight into the normal function of the postoperative stomach than artificial stimulation by histamine. It is interesting to note that in 107 patients, or 41 per cent (Table IV), in

whom an acidity was reported following operation, 9, or 8 per cent, had complications, but the group with the lowest average acidity showed the highest percentage of well patients. In the group in which postoperative complications developed, although these patients were well and were so grouped, 10 patients recovered on a medical regimen. In 4 patients who had adhesions, obstruction of the efferent loop developed and necessitated a celiotomy to free the obstructed loop. The signs and symptoms of the complications overlap in the 32 cases (Table III). In only 2 instances was the ulcer actually a marginal ulcer; in all other instances the ulcers formed in the jejunum opposite the stoma or just distal to it in the efferent loop. In those that perforated, the perforation was on the anterior wall of the jejunum which had become adherent to the anterior abdominal wall. Penetrating jejunal ulcers that were associated with severe hemorrhage had eroded into the mesentery of the jejunum. In the case of patients listed as having jejunal ulcers verification was made at operation. Those cases in which the patients did not undergo a second operation were simply classified under pain, hemorrhage, or both.

Patients placed on the improved list ranged from those having very mild symptoms to those having more severe ones. The margin between well and improved was a narrow one, because if the patients had any symptoms or signs whatsoever they were not grouped with the well but with the improved. This group consists of 30 patients, or 12 per cent. In addition to the other data (Table III) it will be noted that the average postoperative free acid was 36 degrees. Also of interest is the presence of a recurrent duodenal ulcer in one patient following a previous pyloroplasty. The ulcer occurred at the junction of the gastric and duodenal mucosa anteriorly. In the improved group some were less improved than others and also demonstrated individual variation from time to time.

Under the classification of unimproved were placed the 21 patients, or 8 per cent, who have resisted completely both surgical and medical therapy. Further resection in three instances in which a very radical operation was performed also failed to protect the patients from a continuation of pain and hemorrhage. It is of interest to note that all of the patients in this group were of a sensitive, high-strung type in which there was a pronounced degree of psychobiologic lability. The average free acidity in this group following their primary operation was 53 degrees, which was much higher than was noted in the well or improved groups. In a consideration of the complications following conservative resection on the 260 patients of this series (Table V) it is noted that pain occurred in 42, or 16 per cent. This pain was assumed to be from a jejunal ulcer and in all instances was referred to the left upper quadrant of the abdomen. This was to be expected, for the pouch of the stomach remaining after resection is located in that region of the abdominal cavity when an antecolic gastrojejunostomy is employed. Marginal or jejunal ulcer occurred in 23 cases, or 9 per cent. In Table VI a summary of the data of this subject is given. A matter of interest which

is not shown in Table VI is that one patient was operated upon five times, four times for postoperative jejunal ulcer. This patient, a medical house officer, is now well after having practically all of his stomach removed. Two patients had three additional operations, and three patients required two later resections, but are now well. Table V also shows that the preoperative

TABLE V

POSTOPERATIVE COMPLICATIONS OF 260 CASES

Complication	No. of Cases	Percentage
Pain	42	16%
Hemorrhage	26	10%
Marginal or jejunal ulcer	23	9%

COMPLICATIONS IN RELATION TO PREOPERATIVE SYMPTOMS

	Complications		
Symptoms	Pain	Bleeding	Ulcer
Pain without bleeding	9% (22 cases)	3% (7 cases)	4% (10 cases)
Pain with bleeding and vomiting	8% (20 cases)	8% (19 cases)	5% (13 cases)

RESULTS ON 260

With complications	32%, or	83 cases
Without complications	66%, or	172 cases
Mortality	2%, or	5 cases
	100%	260 cases

signs and symptoms have very little relation to the probable postoperative complications. Altogether, taking into consideration the entire series, it is seen that in 83 patients, or 32 per cent, complications developed whereas 172, or 66 per cent, remained well. Five cases, or 2 per cent, died following the operation. The sources of bleeding determined were (a) from the mesenteric vessels of the jejunum, often severe; and (b) from multiple erosions

TABLE VI

MARGINAL ULCERS

9% (23 cases) of 260 developed jejunal or marginal ulcers
- 67% (15 cases) were reoperated out of above 23 cases
  - Present results of 15 cases reoperated:
    - Well 80% (11 cases)
    - Improved 20% (2 cases)
    - Unimproved 20% (2 cases)
- 33% (8 cases) of above 23 cases were not reoperated
  - Present results all unimproved

Gastric acidity: Preoperative for marginal ulcer—Average G.A. 36 free acid
Postoperative for marginal ulcer—Average G.A. 12 free acid
Symptoms of those with marginal ulcers:
- 33% (8 cases) had hemorrhage
- 20% (5 cases) perforated
- 37% (10 cases) had pain alone

100% 23 cases—Total

of the jejunum, more often not serious. Table VII shows that 26, or 10 per cent, of the 260 patients suffered from postoperative hemorrhage of varying degrees of severity. Of these 38 per cent were again operated upon. One of them, who died from hemorrhage following operation elsewhere, had been classified as unimproved. Among those treated surgically and classified as improved were the patients having only occasional slight bleeding following operation which was detected by examination of their

stools. Sixteen patients, or 62 per cent, were treated medically with the greater number falling in the improved and unimproved groups. There were no fatalities among the 16 patients treated medically. The source of bleeding in this group of patients, of course, was not determined, but none of these seemed to be more than temporarily incapacitated.

TABLE VII

HEMORRHAGE

10% (26 cases) of 260 had postoperative hemorrhages
38% (10 cases) of above 26 cases were reoperated. Present results:
Well.....50% (5 cases)
Improved.....24% (3 cases)
Unimproved.....16% (2 cases)
62% (16 cases) of above 26 cases were not reoperated. Present results:
Well.....44% (7 cases)
Improved.....12% (2 cases)
Unimproved.....44% (7 cases)

OPERATIVE TECHNIC

A midline incision has been employed because exposure of the lesser curvature of the stomach, and, thus, the left gastric artery and coronary vein, is more easily accomplished with less vigorous retraction by this route than through a high right rectus incision. The less the degree of retraction the better the relaxation of the abdominal wall. In the upper abdomen the midline incision traverses the linea alba which is the most avascular portion of the abdominal wall. Obviously, there is no interference with the nerve supply to the rectus muscle or further weakening of that structure from direct trauma in splitting its fibers. The round, or falciform ligament of the liver lies immediately beneath the linea alba, but under the right lip of the incision, the reflection of the peritoneum to cover the ligament may be incised and the entire body, *i.e.*, ligament, fat and peritoneum, reflected laterally. When the peritoneum is incised somewhat to the right of the reflection of the round ligament, it is not necessary to suture the edges of the former when closure of the abdomen is made. The round ligament falls into its normal position covering the posterior surface of the wound as a peritoneal flap, when the linea alba and thus the abdominal wall is closed.

The location of the common duct and its point of disappearance behind the upper part of the second portion of the duodenum has been made a routine preliminary step in the operation. The knowledge of the position of this duct affords not only more confidence but also more safety in a liberal mobilization of the second part of the duodenum for resection of ulcers in this region. At the same time, such a free dissection enables the operator to effect a more secure closure of the duodenal stump. The left gastric vessels and right vagus nerve are then divided and ligated with medium "c" silk. Following this, vessels running in the gastrohepatic and gastrocolic as well as the duodenohepatic and duodenocolic ligaments are individually clamped and ligated with "c" silk. Thus, the entire lower fifth or pyloric antrum of the stomach, together with the first and upper two-thirds of the second portion of the duodenum are thoroughly mobilized and

the latter freed from the head of the pancreas. A medium-sized Payr crushing clamp is now placed across the body of the stomach at approximately the midportion of the stomach. The stomach is divided and the posteromedial surface of the duodenum is freed from the head of the pancreas. Due to the fact that the common duct lies between the head of the pancreas and the medial wall of the duodenum, a portion of the latter may be removed

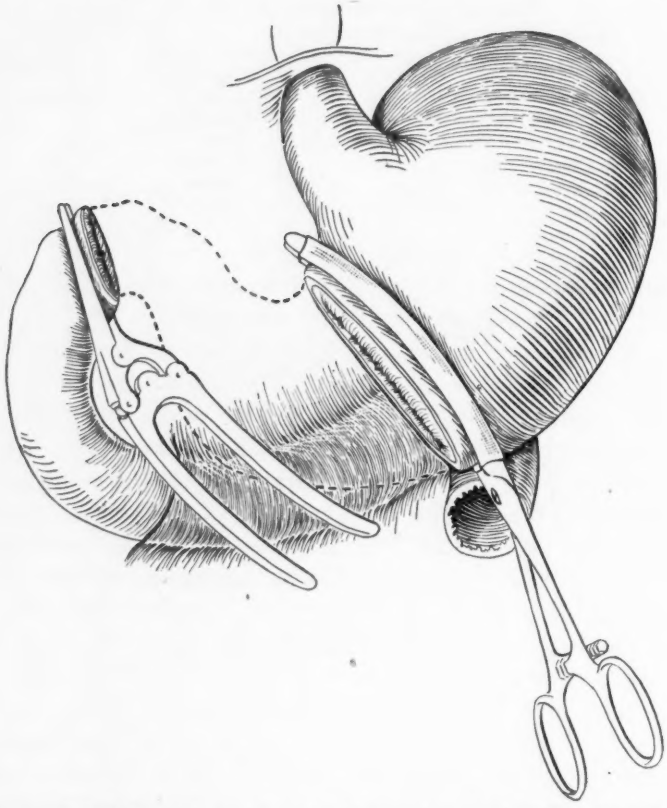

FIG. 1.—Dotted line demonstrates portion of stomach removed which includes first part of duodenum, pylorus, pyloric antrum and fundus up to incisura angularis.

without danger of injury to the former. The duodenum, having been mobilized may be clamped across with a small Payr crushing clamp, or, and in some instances a method to be preferred is to open the duodenum and after inserting the finger into the open end to dissect the ulcer on the finger very much like the technic employed in mobilizing a hernial sac. The pyloric antrum, and pyloric sphincter, together with a portion of the fundus of the stomach are then removed (Fig. 1). The stump of the duodenum is closed with two layers of sutures (Fig. 2) the first a continuous suture of "0" chromic catgut. This is placed underneath the crushing clamp in such a manner that the crushed tissue beyond it can be cut off without danger of cutting the suture line. The advantage of removing this crushed tissue, which will become necrotic, is obvious. With this type of suture only

viable tissue is turned in. Interrupted Halsted sutures of fine "a" silk are then used to invert the first continuous suture line. It is frequently a most gratifying surgical procedure if one inverts the duodenum from the midline laterally instead of in the vertical plane (Fig. 3). The reason for this is that less of the duodenum need be freed from the head of the pancreas, which in some instances, because of penetrating posterior wall ulcers, may be a formidable undertaking and one fraught with danger due to the difficulty

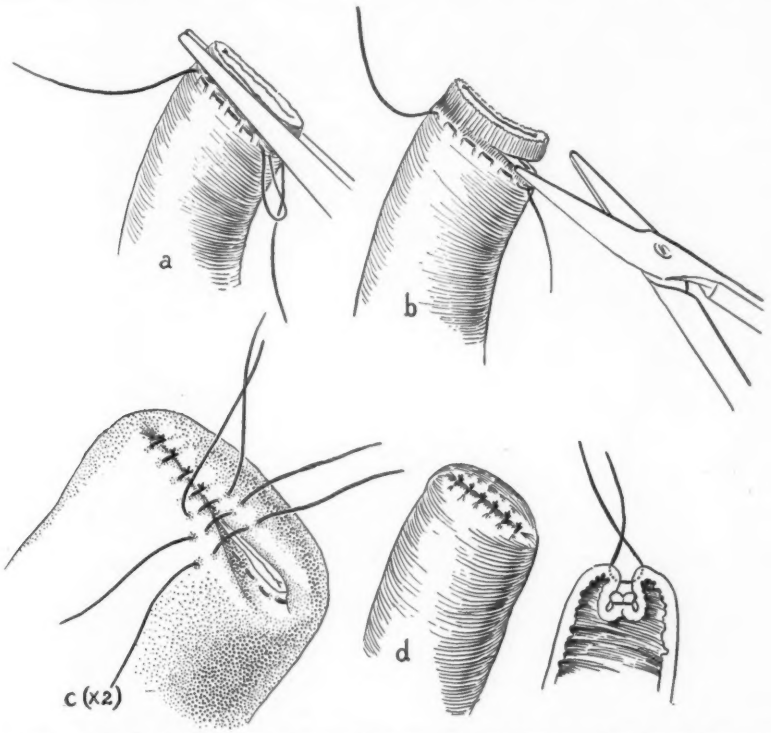

FIG. 2.—Method of closure of duodenal stump. (a) Application of continuous mattress suture of O chromic catgut beneath crushing clamp, (b) trimming off crushing tissue distal to suture line, (c) Turning in duodenal stump with interrupted Halsted sutures of fine silk, (d) Turn in completed, showing cross section of inturned portion of duodenum.

of turning in the scarred base. All bleeding points about the head of the pancreas are transfixed with fine silk. Care is taken to insert a small part of the beginning or extreme right portion of the gastrocolic omentum between the raw surface of the head of the pancreas and the duodenum, in order to prevent any possibility of digestion or erosion of the stump of the latter. Attention is then turned to the reëstablishment of the continuity of the gastrointestinal tract. Due to the relatively small segment of stomach removed, a short-looped antecolic gastrojejunostomy can be performed readily and without the necessity of an entero-enterostomy. The colon and greater omentum are returned to the peritoneal cavity by shunting them to the left of the proximal loop of the jejunum. When this latter portion of the intestine is sewn to the cut-end of the stomach, the distance between

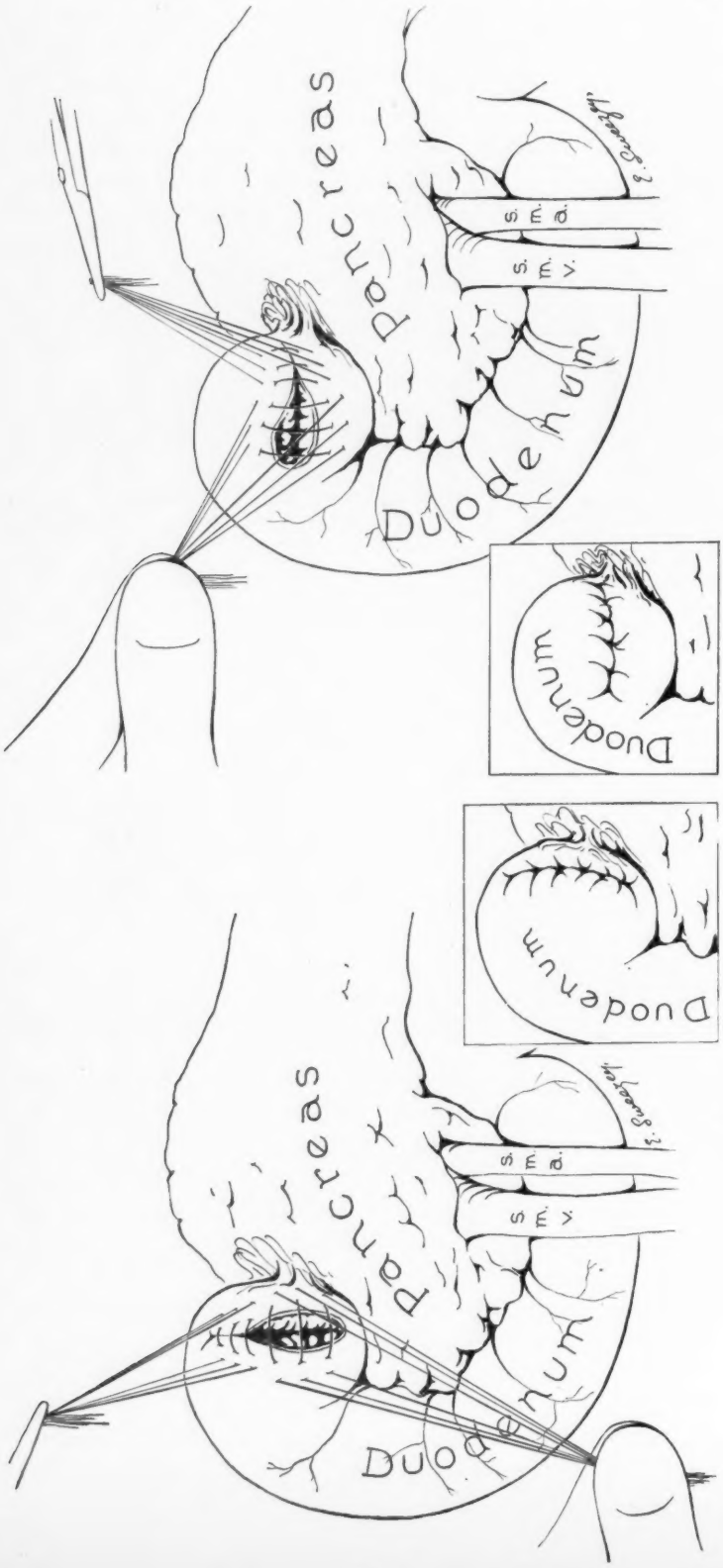

FIG. 3.—Demonstrates the vertical and lateral closure of the duodenal stump.

Treitz's ligament and the beginning of the gastrojejunal anastomosis at the lesser curvature of the stomach is only three fingers' breadth. A few centimeters proximal to the Payr crushing clamp, a noncrushing clamp is placed

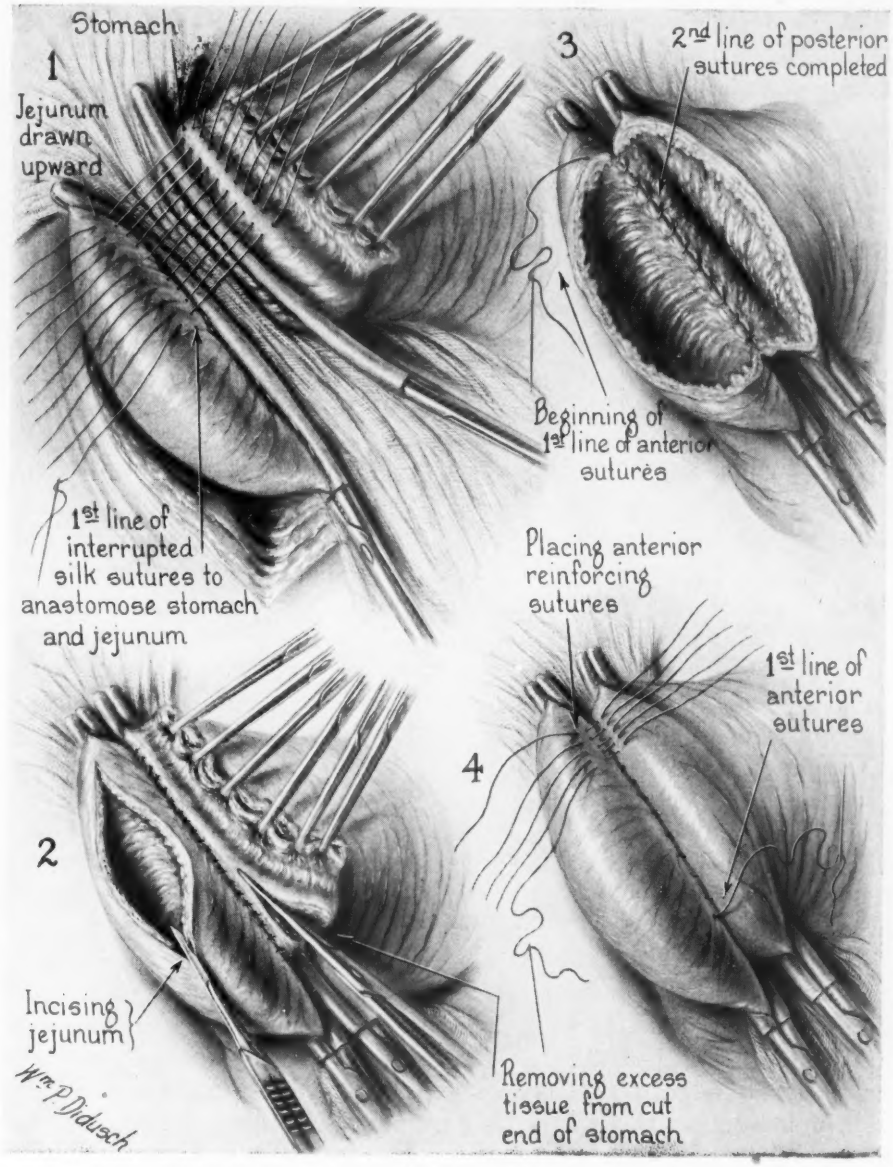

FIG. 4.—Method of reëstablishment of continuity of gastro-intestinal tract by antecolic gastrojejunostomy. Crushed tissue is removed from the stump of the resected stomach.

upon the stomach and a similar one upon the jejunum. Gauze webbing is used to cover the blades of the noncrushing intestinal clamps in preference to rubber, the former having the advantage of being far less bulky and

affording much greater purchase, and, therefore, capacity to hold with less pressure exerted on the tissue through the blades of the clamp. The Payr crushing clamp is then removed and mucosa clips are placed upon the cut-end of the stomach embracing only the crushed portion of the stomach wall, while the imprint of the Payr clamp is plainly visible (Fig. 3). Halsted interrupted fine silk sutures are then inserted about 0.5 centimeters apart as the posterior suture line. The entire line is placed before any of the sutures are tied, thus, allowing more room for inserting successive sutures accurately than if they are tied as placed. The crushed portion of the stomach wall, which has been grasped by the mucosa clips, is then excised. The posterior interrupted suture line is much more easily and accurately placed if the mucosa clips are allowed to remain on through this step in the operation. This is due to the fact that the clips, lying in such a manner that their handles point to the left, cause the posterior wall of the stomach to be thrown anteriorly and place it in a more convenient position for suturing. The jejunum is then opened and a continuous suture of No. 1 chromic catgut is placed as an internal suture line in both the posterior and anterior lips of the mucosa. These stitches are locked only at the ends, to prevent any chance of diminution of the stoma by constriction. The final anterior row of Halstead interrupted "a" silk sutures is placed in position before the noncrushing intestinal clamps are removed, but they are not tied. This is accomplished after the stomach and intestine have been released from the noncrushing clamps. In this manner the sutures are more accurately placed and then tied without exerting any tension on the wall of the viscera. A couple of interrupted sutures are placed between the lateral wall of the proximal loop of the jejunum and the transverse mesocolon to prevent a loop of jejunum lower down from slipping through this potential opening. The anastomoses have so far been made isoperistaltic with the proximal loop sewn to the lesser curvature (Fig. 4).

The abdomen is closed in the following manner: The linea alba with interruped double medium silk and the skin with interrupted fine silk sutures.

DISCUSSION.—In what may be termed a continuing study of 260 patients who were operated upon for peptic ulcer of the duodenum of from 4 to 20 years' duration, the results indicate that only 204 patients, or 78 per cent, should be regarded as well, 30 patients, or 12 per cent, as improved, and 21, or 8 per cent, as unimproved. The immediate mortality was 2 per cent, with no deaths occurring in the last 160 cases. These patients were operated upon because of complications arising from a chronic peptic duodenal ulcer that would not respond to medical treatment. The complications consisted of intractable pain, hemorrhage, and vomiting associated with pyloric obstruction. In other words, the duodenal ulcer, or ulcers, had continued to erode, eventually involving contiguous structures such as the pancreas, in spite of the fact that those patients had cooperated to the fullest extent in following a strict medical regimen. Because these patients, generally speaking, had a more intelligent and better informed attitude than ward patients, they

had sought operation before their complications had so reduced their vitality as to make any operation precarious.

A conservative resection of the stomach and first portion of the duodenum was performed because resection, while far from ideal, was thought

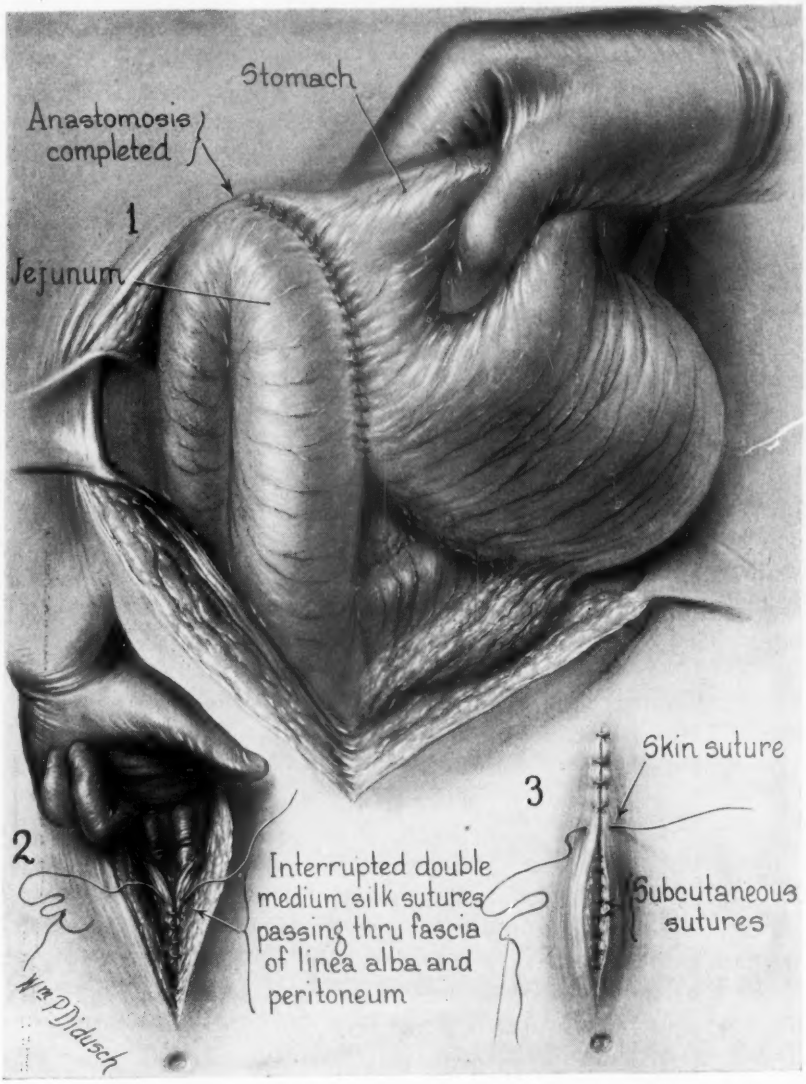

FIG. 5.—The anastomosis completed, antecolic gastrojejunostomy—Pólya-Balfour type.

more efficacious than less radical procedures such as gastro-enterostomy. The advantages in the type of operation employed will be discussed later. In brief review, the surgical procedure has been (1) to remove the pylorus, pyloric antrum, and a portion of the acid-secreting mucosa of the fundus; (2) to shunt the flow of acid chyme and food away from the ulcer-bearing

area of the duodenum; and (3) to employ a type of anastomosis which insures the maximum irrigation of the remaining pouch of stomach and at the same time prevents pooling of gastric juice and food due to delayed emptying. The rationale of the operative procedure, an antecolic gastrojejunostomy, is based upon the following considerations: (1) If the flow of gastric contents can be diverted from the duodenum, chronic peptic ulcers of this structure will heal or will fail to recur when excised. In over 75 per cent of the patients in this series the ulcers were left *in situ* and apparently healed. (2) The operation must protect the patient from the development of post-operative complications in the jejunum such as peptic jejunal ulcers or hemorrhagic jejunitis. (3) The original operation must have been so performed that in the event of jejunal complications secondary operations may be carried out with minimal technical difficulty and operative mortality.

All observers apparently agree upon the fact that chronic ulcer of the duodenum, with very few exceptions, will heal if put to rest by diverting the flow of gastric contents away from the ulcer-bearing area of the duodenum. Extensive and hazardous dissections of ulcers located in the lower portion of the duodenum are unnecessary. If the ulcer is on the posterior wall and has produced massive hemorrhage and the patient is in shock, the better procedure is simple transfixion or cauterization, or both, of the bleeding vessel in the base of the ulcer.

There seems to be a lack of unanimity of opinion, however, in regard to the extent of resection and the type of operation to be employed. Although it is difficult to estimate accurately the amount of stomach removed at operation, one usually thinks more of the organ has been resected than actually was removed because the size of the stomach varies. It is possible because of anatomic landmarks to arrive at a certain degree of uniformity in operative procedure. In this series, division across the fundus of the stomach, was made at right angles to the curvatures, greater and lesser, at the level where the left gastric vessels leave the lesser curvature and spread over the anterior and posterior surfaces of the stomach. This area corresponds anatomically with the incisura angularis. This procedure insures removal of roughly 50 per cent of the organ including the pylorus, the pyloric antrum, and about one-third of the acid-secreting area. The removal of the antral mucosa is felt to be important because of the elimination of the hormone gastrin, the chemical stimulant for the formation of gastric juice. Also removed is an indefinite amount of acid-secreting mucosa.

The results in this series seem to indicate that conservative resection of the stomach may be carried out with an immediate mortality as low as that following gastro-enterostomy. Therefore, this type of resection is to be preferred to gastro-enterostomy in the kind of case under discussion. The remote results also indicate that resection, regardless of the extent short of almost total gastrectomy, will not insure against the development of jejunal complications. This was demonstrated in this series in a few persons with pronounced ulcer diasthesis and others upon whom it was necessary to operate

two, three, four and even five times for recurring peptic jejunal ulcer. One point seems certain, however, and that is that the majority of patients who are well are those with the lowest degree of free acid. There are a few who, despite high postoperative free acid, are asymptomatic, but they are exceptions to the general rule. The patients in the improved and unimproved groups tend to support this observation. Another well known and supporting fact is that peptic ulceration of the jejunum does not occur following gastric resection for carcinoma of the stomach. The success or failure of a resection of the stomach for peptic ulcers of the duodenum depends, therefore, in the majority of patients, on permanent reduction in gastric acidity under the normal circumstances of the patient's everyday life. This reduction is accomplished in three ways: (1) By removal of the acid-stimulating hormone gastrin; (2) by reduction of the acid-bearing area by partial removal; and (3) by neutralization of the acid juice by a thorough mixing with the alkaline jejunal contents. Individuals differ in the secretion of acid-pepsin gastric juices as they do in every other function of the human body but these results suggest that, either by neutralization of the acid gastric juice or by partial excision of the acid-bearing mucosa, the majority of patients in this series struck a favorable acid balance following this type of conservative resection of the stomach. Adequate mixing of gastric and jejunal contents and prompt emptying time of the remaining gastric pouch to prevent pooling of food and gastric juices are considered to be of great importance. The very low immediate mortality rate adds to the desirability of conservative resection. In the relatively small percentage of patients in whom evidence of persistence of high free acid is found together with either the signs or symptoms of jejunal erosion or ulcer, a further radical resection may be performed.

SUMMARY

The fact that patients in whom chronic peptic ulcer develops have a psychobiologic lability above normal is well recognized. The reason for the unstable clinical status observed in this postoperative study is, therefore, not far to seek. There are many shades and nuances between the well group and the improved group, and also among the individuals comprising these groups. Most of the postoperative complications appear to occur within the first two years, but they may occur at any time later. Gastric resection is the best method available at present for the treatment of the complications of chronic peptic ulcer of the duodenum but is not ideal in that it is only relatively better than less extensive surgical procedures. This report is made in order to serve as a basis for future comparison and study, and it may be said to result from a search for a surgical procedure which combines in the highest degree both safety and efficacy.

TRANSTHORACIC GASTRECTOMY FOR UNUSUAL LESIONS OF THE STOMACH*

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MALIGNANT TUMORS of the proximal portion of the stomach are relatively silent unless they cause obstruction of the cardia. Even after the symptoms of dyspepsia appear, diagnosis may be delayed because of difficulty in visualizing early lesions of the fundus by barium study. Extragastric extension into the liver, diaphragm, spleen or lesser peritoneal cavity, as well as the regional lymph nodes, is often present before the patient comes to surgery. Tumors of the cardia may extend some distance up the esophagus and tumors of the lower esophagus may invade the proximal stomach. Until recent years, these factors rendered most malignant tumors of the cardia and fundus inoperable. Even since the development of transabdominal total gastrectomy with esophagojejunostomy, the technical difficulties of working up under the dome of the diaphragm are considerable when there is extragastric extension of the tumor, and involvement of the diaphragm or lower esophagus may make transabdominal resection impossible. Within recent years, reports of transthoracic approach to these tumors have been increasingly frequent.[1, 2, 3, 4, 5, 6, 7]

The advantages of the transthoracic approach are (1) more direct accessibility and better exposure of the involved structures within the abdomen; and (2) the ability to deal with extensions of the tumor in the diaphragm and lower esophagus. The disadvantages are (1) the possibility of infection in the mediastinum and pleura; and (2) somewhat longer operating time. To this may be added the reluctance of many abdominal surgeons to invade the thorax. Careful technic, avoidance of contamination, and meticulous attention to the details of anastomosis will minimize the danger of infection. The use of fine interrupted sutures of nonabsorbable material throughout is of particular value. Prophylactic use of the sulfonamides or penicillin may be of some importance.[8] Gentleness, good hemostasis, and adequate replacement of blood loss, combined with expert anesthesia, make the operating time of little importance.

Preoperative Preparation.—This need be no different than for any major gastric operation. Defective dental hygiene should be corrected. Hemoglobin, protein, and other chemical deficiencies should be restored to normal. Since few of these patients have gastric stasis, gastric drainage or lavage is not so important as in lesions of the distal stomach, but lavage of the esophagus should be done if there is obstruction at the cardia. The administration of dilute hydrochloric acid is advisable if achlorhydria is

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present, in order to reduce the bacterial flora. Establishment of an adequate blood level of sulfadiazine or the administration of penicillin in doses of 15,000 units every three hours for 48 hours preoperatively, may decrease the danger of infection.

Anesthesia.—The most important factor in anesthesia is the expert anesthetist. He must have a full understanding of modern anesthesia and of respiratory physiology and must possess the ability to anticipate and prevent changes in the patient's condition. My preference has been for endotracheal ether-oxygen anesthesia, with thorough aspiration of the pulmonary tree at the end of operation.

Operative Technic.—The patient is supported on his right side so that a field from the midline posteriorly to the midline anteriorly on the left side is available. An incision is made over the 8th, 9th or 10th rib according to the obliquity of the ribs, and the rib resected from the angle to the costal margin. This position and incision allows extension across the costal margin and upper left abdomen if this should be necessary. The thorax is explored and mediastinal lymph nodes palpated for evidence of metastasis. The lung is then packed away into the upper chest and the phrenic nerve crushed low at the side of the pericardium to immobilize the diaphragm and prevent tension on the suture lines postoperatively. The mediastinal pleura over the esophagus is incised as far upward as may be necessary and the incision carried across the diaphragm from the esophageal hiatus to the costal margin. Bringing the anterior end of the diaphragmatic incision to the same point as the anterior end of the thoracic incision allows the abdominal and thoracic cavities to be converted into one, if it is necessary to extend the incision onto the abdominal wall. The abdomen is explored for metastases and the operability determined. We have routinely removed the spleen in order to increase exposure and facilitate the rest of the procedure. The lower esophagus is freed from the mediastinal structures and the vagus nerves divided above the diaphragm. Section of these nerves considerably increases the mobility of the cardia. The greater curvature of the stomach is freed and dissection carried behind the stomach to the gastric vessels which are ligated and divided close to the celiac axis. This dissection is carried out retroperitoneally if there is involvement of the posterior wall of the stomach, removing the posterior peritoneum of the lesser sac down to the pancreas. The lesser curvature is freed along with the entire gastrohepatic omentum and the lymph nodes of the lesser curvature. The stomach and lower esophagus are now quite mobile and may be lifted almost to the surface of the thorax. The stomach is divided between clamps with the cautery as low down as necessary to get well below the tumor. It is possible with this exposure to perform a total gastrectomy, utilizing the jejunum for the subsequent anastomosis. Usually, however, a considerable portion of stomach may be left. Closure of the stomach is carried out with two layers of interrupted fine silk inverting sutures, and the tip of the greater curvature is sutured to the posterior thoracic wall to reduce tension on the subsequent suture line, as

advocated by Carter.[1] The esophagus is divided between clamps and the specimen removed. The proximal esophagus is emptied by aspiration through a tube which has been previously inserted from above, and aspiration is continued throughout the remainder of the anastomosis. The esophagus is sutured to the anterior surface of the stomach for a distance of an inch or more to minimize tension. An opening is made in the anterior surface of the stomach equal in length to the diameter of the esophagus and an

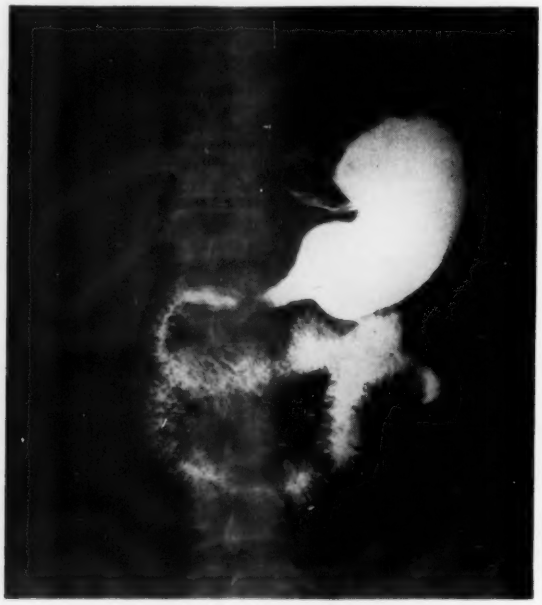

FIG. 1.—Case 1: Barium study showing deformity of fundus.

open anastomosis carried out in two layers with interrupted fine silk sutures. The anastomosis may be reinforced with any available tags of omentum. Any fluid or clots remaining in the abdomen are removed by suction and about 2.5 grams of sulfanilamide crystals dusted about the anastomosis. Margins of the diaphragm are then sutured to the stomach well down from the anastomosis so that there will be no pull on the suture line. The remainder of the diaphragm is overlapped a distance of about one centimeter and closed with mattress sutures of interrupted silk. The thoracic cavity is cleaned and dried and about 2.5 grams of sulfanilamide dusted over the surface of the diaphragm. The chest wall is closed in layers with silk without drainage after the lung has been inflated by the anesthetist.

Postoperative Care.—One or two transfusions have usually been given during the operation. These are supplemented by additional transfusions postoperative as indicated. The esophageal tube which has been pushed into the stomach is connected with constant suction, which is maintained for about 72 hours, at the end of which time liquids may be cautiously given by

mouth. Meanwhile, the usual postoperative supportive measures and the maintenance of adequate fluid intake parenterally have been carried out. Any accumulation of fluid or residual air in the left pleura is removed by aspiration at proper intervals. When fluids are started they are administered in amounts of one ounce every 30 minutes if tolerated well. This can rapidly

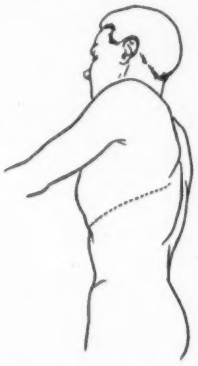

FIG. 2.—Line of incision from angle of rib to costal margin. Incision is made over eighth, ninth or tenth rib according to obliquity of ribs.

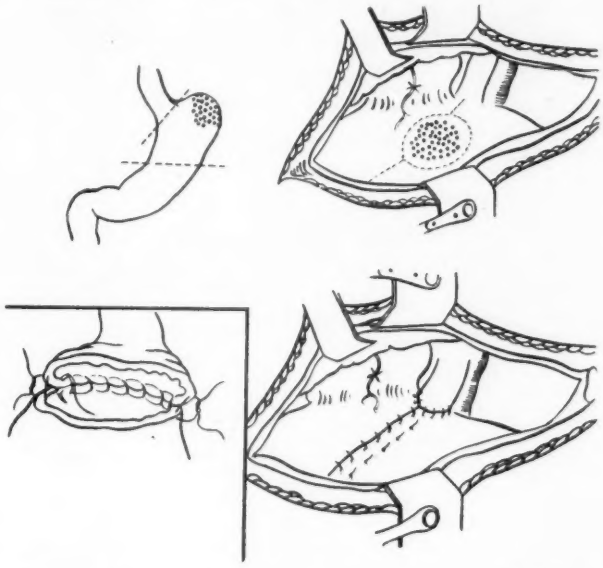

FIG. 3.—Case 1—Upper left: Diagram of tumor and lines of resection. Upper right: Invasion of diaphragm by tumor with line of incision in diaphragm. "X" shows point of crush of left phrenic nerve. Lower left: End-to-end anastomosis of cardia and antrum. Lower right: Suture of diaphragm and closure about esophagus.

be stepped-up and the amount and consistency of feedings increased until at the end of ten days the patient should be on a full soft diet, and at the end of the third week should be taking a full normal diet.

Case 1.—Register No. 213573. White, male, age 49.

Family and past histories were irrelevant. Present illness began about November, 1943, with dysphagia, regurgitation of solid food immediately after eating, and epi-

FIG. 4.—Case 1: Postoperative roentgenogram showing small normal appearing stomach.

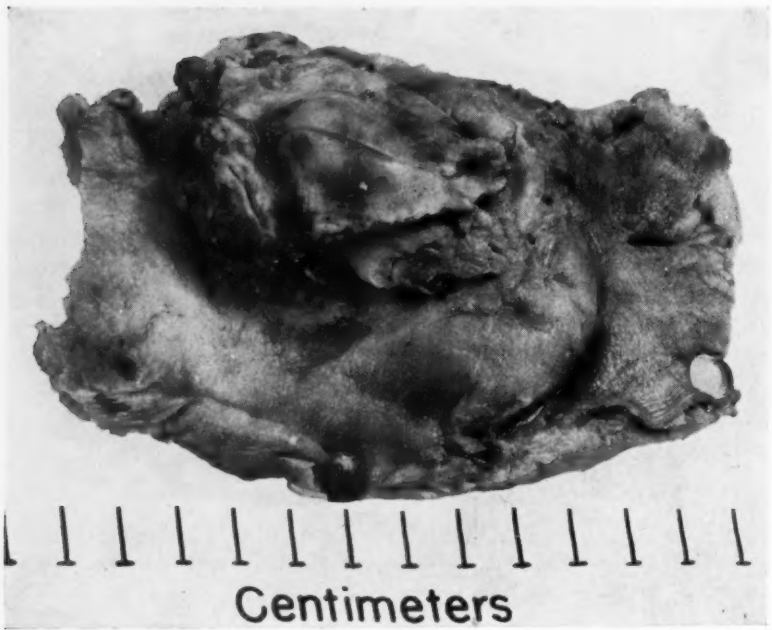

FIG. 5.—Case 1: Outer surface showing triangular portion of diaphragm infiltrated by tumor.

gastric pain accentuated by food and relieved by emesis. There was some loss of weight. Because of these symptoms in December, 1943, a gastro-intestinal series was done at the out-patient service of an overseas hospital, with indefinite findings of a small deformity on the greater curvature near the cardia. Gastroscopy showed a patch of atrophic gastritis, and at 1500 in the antrum, a peculiar pouch giving the impression of being pulled transversely. A second gastro-intestinal series March 30, 1944, was reported as negative. Because of continued symptoms, he was admitted to a hospital overseas on April 20, 1944. Physical examination there showed nothing re-

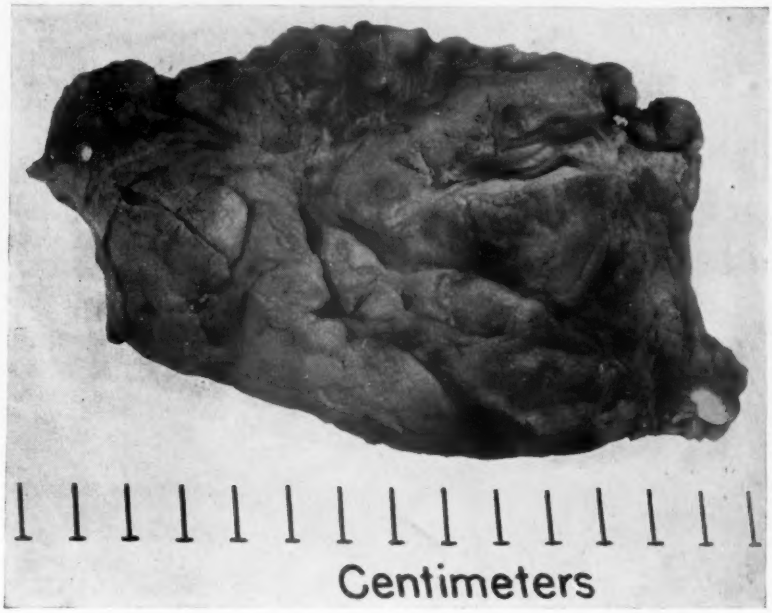

FIG. 6.—Case 1: Mucosal surface of stomach showing three distinct infiltrating masses of tumor with ulceration of the overlying mucosa.

markable except tenderness in the epigastrium without palpable mass. Gastric analysis showed complete achlorhydria and gastro-intestinal series showed what was considered to be carcinoma, moderately advanced, inoperable, involving cardiac portion of the stomach.

He was transferred to Walter Reed General Hospital May 8, 1944. Physical examination showed evidence of considerable weight loss. There was slight tenderness to the right of the umbilicus and in the epigastrium, but no abdominal masses were felt. Examination was otherwise essentially normal. Fluoroscopic examination May 9, showed what appeared to be an ulcerative carcinoma of the cardiac end of the stomach (Fig. 1). Usual laboratory examinations were within normal limits. On May 19, he vomited a small amount of blood.

Operation.—May 22, 1944: Incision was made over and parallel to the left 10th rib and the rib resected subperiosteally from the angle to the costal margin (Fig. 2). The pleura was opened and the left lung collapsed. There were a few shotty calcified lymph nodes in the mediastinum. The tumor of the stomach had invaded the diaphragm over an area of about one inch in diameter (Fig. 3), but there was no gross penetration of the upper surface of the diaphragm. Except for the tumor in the fundus, the stomach was free and there were no palpable lymph nodes. The incision in the diaphragm was continued as an ellipse well around the infiltrated area and back to the esophageal hiatus.

Lower esophagus and upper portion of the stomach were dissected free and the spleen removed to increase exposure. As dissection progressed it could be seen that the tumor did not quite involve the cardia but was confined to the fundus on the greater curvature. Gastric vessels were identified and exposed close to the celiac axis where they were ligated and divided. After freeing both curvatures of the stomach, stomach was transected with the cautery between clamps at about the midportion. Dissection was carried upward behind the stomach and a portion of the left lobe of the liver, which was adherent to the

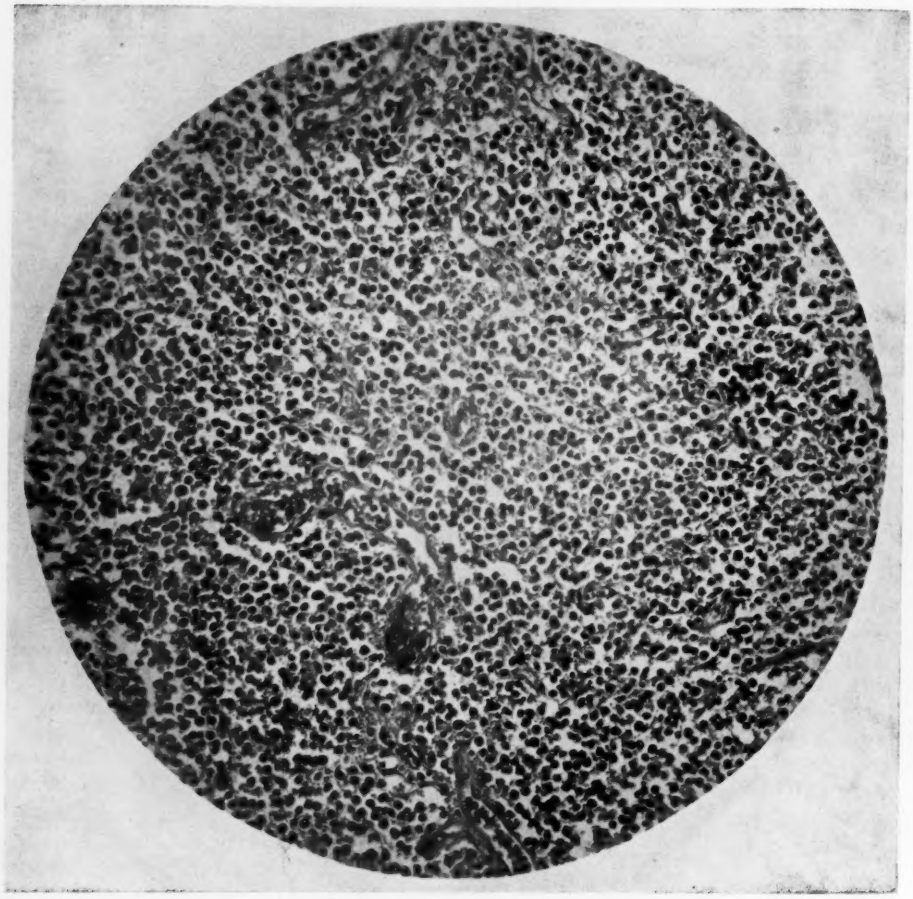

FIG. 7.—Case 1: Section through tumor showing the loose distribution of the cells in a fine reticular stroma which is quite vascular.

tumor, was excised. As the dissection progressed it was evident that it would be possible to save a cuff of the normal stomach at the cardia from one-quarter to one inch wide. (In view of the later course, this was probably an error). Incision was made along this line and the intervening portion of stomach removed. An end-to-end anastomosis was carried out between the distal portion of the stomach and the stump at the cardia. A good firm anastomosis resulted and the line of anastomosis was protected by omentum. The diaphragm was sutured above the anastomosis. Two and one-half grams of sulfanilamide had been placed in the abdomen before closure of the diaphragm, and another two and one-half grams placed in the pleura. The lung was reëxpanded and the thoracic wall closed in layers without drainage.

Postoperative course was somewhat slow. The incision healed well. Bloody, serous fluid was aspirated from the left thorax on three occasions. On July 3 roentgenotherapy was started. He received 20 treatments with the one million volt machine, for a total dose of 4,000 r. to the anterior epigastrium and 4,000 r. to the posterior epigastrium. About mid-August he developed severe pain in the region of the operative procedure along the distribution of the 11th intercostal nerve. This was thought to be due to trauma from retractors used to hold the wound in apposition during suturing. This nerve was sectioned September 11 with some relief. Esophagoscopy September 8 showed a wide open anastomosis with no abnormalities. Patient still complained of pain in back, sleeplessness, restlessness, and anorexia. Roentgenograms showed no metastases to

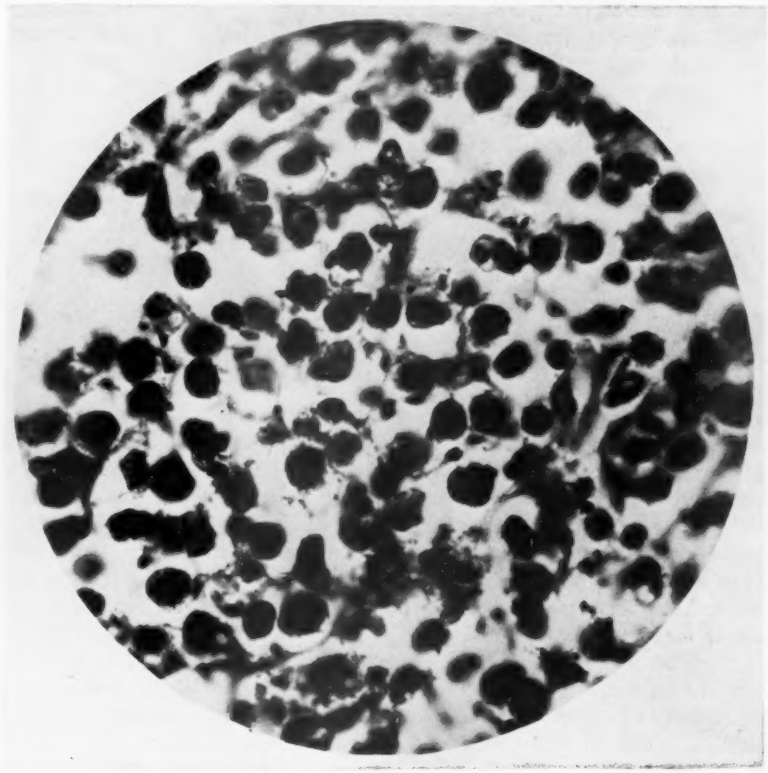

FIG. 8.—Case 1: Oil immersion showing typical neoplastic reticulum cells. Note the pleomorphic tendency of the deeply staining nuclei and the irregular somewhat frayed cytoplasm. A fine reticular structure is seen in this routine H & E preparation.

lungs, bones of thorax, spine, or pelvis. Barium passed freely through lower esophagus into stomach and emptied readily into duodenum. Cardiac portion of stomach appeared normal (Fig. 4). About one month after discharge from the hospital, October 25, 1944, he entered a large civilian clinic because of the pain. Exploration of the mediastinum in November, 1944, at that clinic showed metastatic tumor in the mediastinum.

Pathologic Report.—Capt. William S. Randall, M.C.: Spleen weighs 115 grams and grossly shows nothing of note. Segment of stomach representing the cardia measures 10 cm. long x 6 cm. deep. On the posterior surface there is a 6 x 5 cm. diamond-shaped portion of diaphragm centrally showing a smooth circumscribed, 2.5 cm. diameter nodule of infiltrating tumor which on section is smooth, grayish-white and glistening (Fig. 5). This tumor extends through the wall of the stomach and on the mucosal surface there

is a 5 x 4 cm. elevated tumor centrally showing a 2 cm. zone of ulceration and necrosis. On the opposite wall there is a 2.5 cm. elevated mass covered with exudate, beneath which the tissues are firm, fairly moist and grayish-white (Fig. 6). The surrounding mucosa is markedly edematous. One small soft node is found in the attached omentum.

Microscopic.—Sections through the ulceration in the stomach reveal complete loss of mucosa and throughout the wall there is a diffuse infiltration of indiscriminately arranged neoplastic cells which show moderate variation in size and shape, but generally round to slightly ovoid (Figs. 7 and 8). The nuclei are quite large, round, and the chromatin is coarsely distributed throughout. In some of the nuclei there is massing of the chromatin around the periphery simulating the nuclear structure of plasmoblasts. Throughout quite a few mitotic figures are noted. There is no stroma and between the cells there is a considerable amount of débris. There are many newly formed blood vessels, particularly over the superficial portion of the tumor. Section through the diaphragm shows widespread neoplastic infiltration and over one surface there is a marked serosal reaction. By means of the Wilder's stain a moderate amount of reticulum is noted which is in intimate relationship to the neoplastic cells. The spleen shows no significant change. One small lymph node found in the omentum reveals no alteration in the architecture. *Pathologic Diagnosis:* Reticulum cell sarcoma, primary, in stomach.

Due to the close similarity of many of the cells to immature plasma forms, the possibility of a plasma cell tumor was considered; however, the predominant cell seems to be of the reticulum type.

Case 2.—Register No. 213780. White, male, age 27.

Family history essentially negative except for death of father following operation for ulcer. Past history: Appendicectomy for acute appendicitis in 1934. Occasional use of alcohol; no tobacco. Present illness: Patient stated he had been subject to dizzy spells and vomiting all his life. About 1941 he noted abdominal distress with sense of fullness, usually coming on after eating too much or too fast. This was relieved by soda or milk. There was no hematemesis or tarry stools. He controlled the discomfort by diet fairly well until a year previous to admission, when pain in abdomen became persistent after meals with radiation to left upper quadrant. He was admitted to a station hospital on April 20, 1944, because of vomiting of blood and tarry stools. There had been weight loss of about 10 pounds in the previous six months. Roentgenologic examination on April 25, 1944, showed a large extramucosal tumor 6 cm. in diameter along the medial wall in the cardiac portion of stomach, without ulceration or other abnormalities noted (Fig. 9).

He was admitted to Walter Reed General Hospital on May 12, 1944. Abdomen was soft with no enlarged organs or masses palpable except for slight, indefinite fullness in upper abdomen. Remainder of physical examination essentially negative. A roentgenogram of the stomach December 14, 1943 (taken during basic training) showed indefinite evidence of a tumor at the cardiac end of the stomach measuring about 2.5 cm. Gastric analysis showed free hydrochloric acid of 20–25–25–0–20. Stools were negative for occult blood. Uranalysis normal; Kahn negative. Initial blood count within normal limits.

Operation.—May 25, 1944: Thorax opened through bed of left 10th rib. No tumor could be felt in the mediastinum and although the abdominal tumor was palpable through the diaphragm, there was no invasion of the diaphragm. The tumor in the fundus of the stomach was freely movable, located just to the left and behind the cardia, involving the cardia. There were no apparent metastases in the abdomen. Lower portion of the esophagus was freed and the spleen was removed to increase exposure. Stomach was mobilized and the gastric vessels divided close to the celiac axis. The lesser and greater curvatures of the stomach were freed at about the midportion and the stomach transected and the distal end closed. Dissection was carried upward mobilizing the stomach and distal esophagus. Since the tumor involved the cardia, clamps were placed across the

FIG. 9.—Case 2: Tumor near cardia on posteromedial portion of stomach.

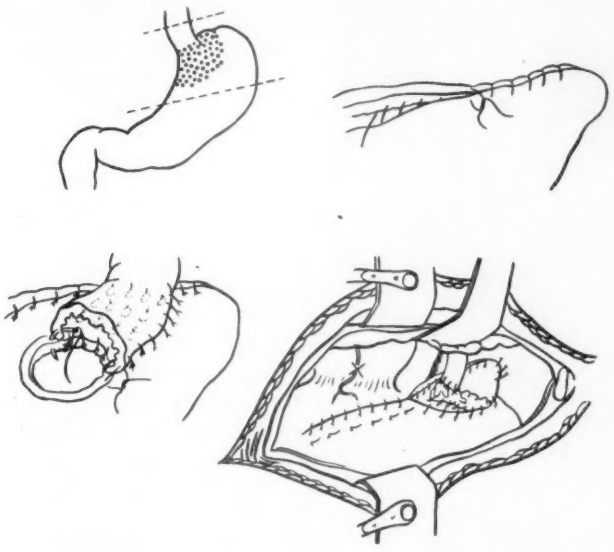

FIG. 10.—Case 2—Upper left: Diagram of tumor and lines of resection. Upper right: Closure of stomach. Lower left: Fixation of esophagus to stomach and anastomosis. Dotted lines show posterior sutures to relieve tension on anastomosis. Lower right: Fixation of stomach to chest wall and closure of diaphragm about stomach, with anastomosis reinforced by omentum.

esophagus above the cardia and the esophagus divided between them with the cautery, removing the upper portion of the stomach and the distal esophagus. This portion of the stomach could be easily brought up into the chest so that the esophageal stump overlapped it without tension. A few silk sutures were taken to tack stomach to the posterior endothoracic fascia. The stump of the esophagus was applied to the anterior surface of the stomach. An opening was made in the stomach and the open end of the esophagus sutured into it. This anastomosis was reinforced by a tab of fat from the omentum of the greater curvature (Fig. 10). Two and one-half grams of sulfanilamide were placed in the abdomen and the diaphragm was closed. Another two and one-half grams of sulfanilamide were placed in the pleura. The wound was closed without drainage after reëxpanding the lung.

FIG. 11.—Case 2: Postoperative barium study showing small segment of stomach above the diaphragm.

Postoperatively there was some collection of fluid and air in the left chest with dyspnea, which was relieved by aspiration. Postoperative course was uneventful. Gastrointestinal series June 20 showed an hiatus hernia (the portion of stomach sutured above the diaphragm) without obstruction to the passage of barium (Fig. 11). Esophagoscopy August 16 showed scar of previous surgery without constriction, tumor masses, or other pathology. At the time of discharge from the hospital, October 11, 1944, he had gained considerable weight and was eating well without pain or nausea.

Pathologic Report.—Capt. William S. Randall, M.C.: Specimen consists of normal spleen weighing 80 grams. There is a portion of stomach and 1.5–2 cm. distal esophagus segment. There is a bulging tumor, 6 x 4.5 cm., in the posterior wall which has infiltrated through the mucosa (Fig. 12). The tumor, on section, is quite soft and friable and has a papillomatous-like structure. There are a few small superficial ulcerations at the cardioesophageal junction. The tumor bulges the mucosa and cause almost complete obstruction to the esophagus (Fig. 13).

Microscopic: Section through the tumor shows widespread replacement of the wall by loosely and compactly arranged spindle-shaped cells which have a moderately fasciculated distribution. The nuclei vary from hyperchromatic to vesicular, some of the latter being quite large with small eccentrically placed nucleoli. Throughout there are fairly frequent mitotic figures without bizarre forms. There is considerable myxomatous-like degeneration in some parts and here there are a few scattered multinucleated tumor cells, these being cut transversely and having a polygonal shape. In one section there is an infiltration into the submucosa with loss of the overlying mucosa which is replaced by a zone of inflammation and granulation (Fig. 14). Throughout there are many thin-walled, markedly dilated blood vessels and scattered small vascular structures, around which the neoplastic cells are radially arranged, forming structures resembling pseudorosettes (Fig. 15). Section of the spleen shows nothing remarkable. *Pathologic Diagnosis:* Leiomyoma of stomach wall showing low grade malignant changes.

Case 3.—Register No. 219413. Colored, male, age 32.

Family history negative insofar as is known. Past history irrelevant. Present ill-

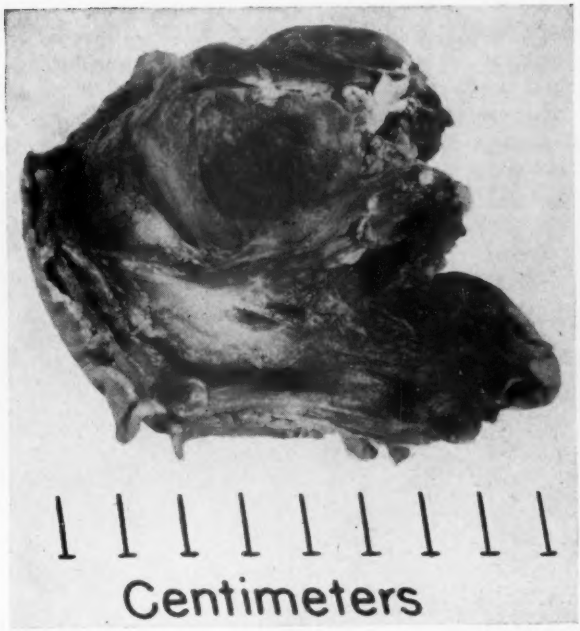

FIG. 12.—Case 2: Outer surface of stomach with bulging tumor which has not infiltrated the serosa.

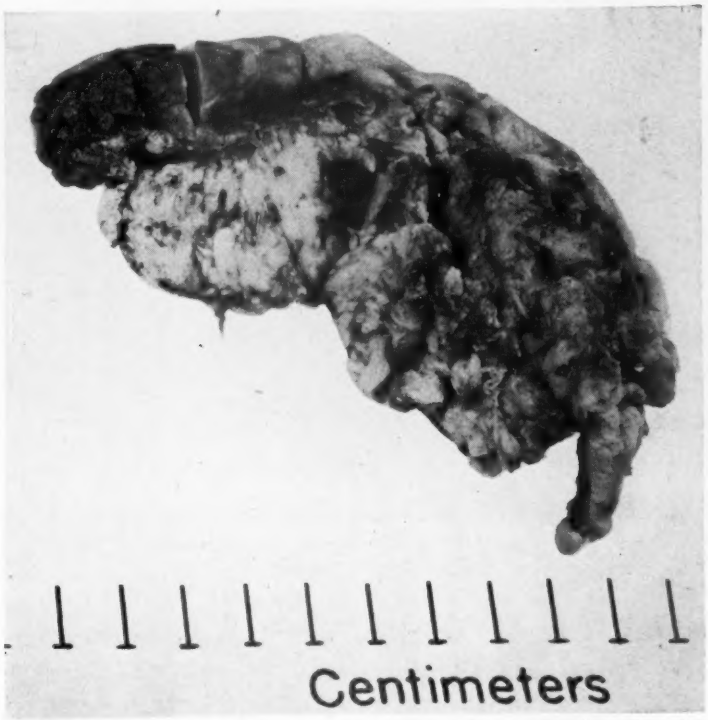

FIG. 13.—Case 2: Mucosal surface with tumor sectioned, occupying the entire wall. Note the white-streaked appearance of the tumor.

ness: Patient first noticed difficulty in swallowing solid food about December, 1943, but did not enter the hospital until August 5, 1944, at which time he complained of pain and vomiting after meals for a period of three months, gradually becoming worse with intolerance to heavy foods, and a persistent feeling of retrosternal heaviness. There has been a loss of about 13 pounds in weight, but no hematemesis or melena. Gastric analysis showed no free hydrochloric acid. Stools were positive for occult blood. Roentgenologic examination August 14, showed obstructive deformity at lower aspect

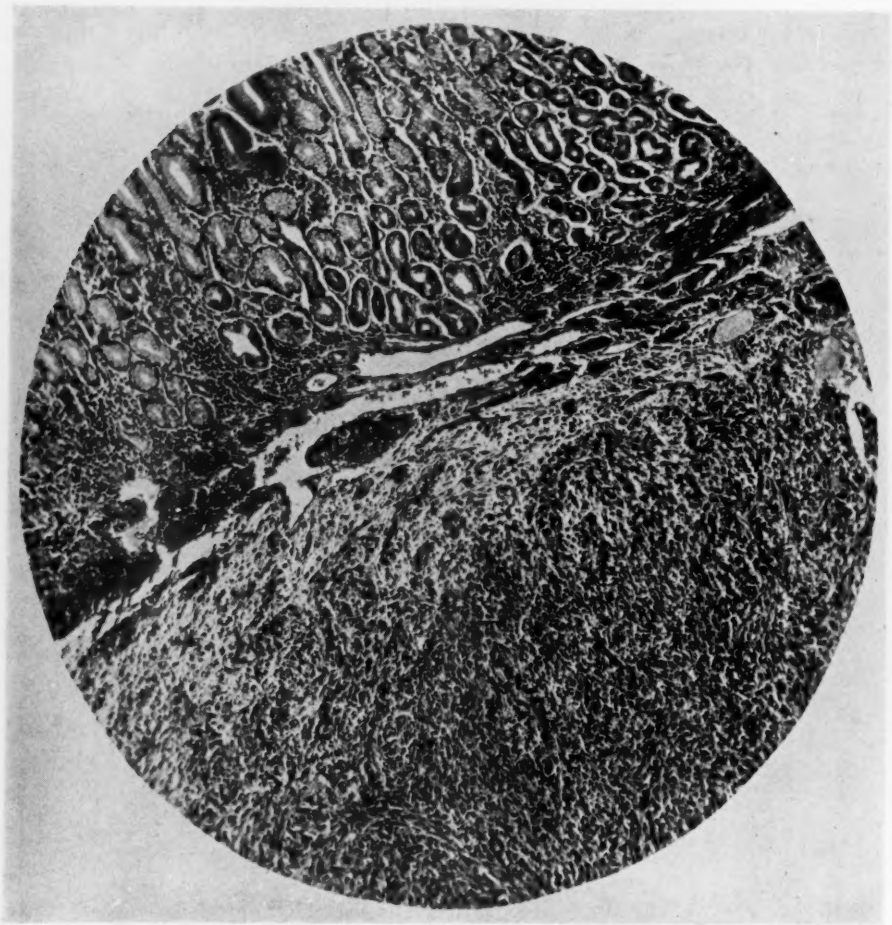

FIG. 14.—Case 2: Section showing submucosal distribution of the tumor.

of esophagus with canalization. Esophagus proximal to lesion was moderately dilated and there was a large filling defect in the region of the cardiac orifice.

He was transferred to Walter Reed General Hospital September 6, 1944. At this time he had lost 25 pounds in weight since December, 1943. Physical examination was essentially negative. Esophagoscopy September 11 showed the esophagus to be normal down to a point about 1.5 inches from the cardia where lumen of the esophagus was almost completely filled with grayish, fungating tumor tissue, springing mainly from the anterior and left lateral walls. Movement of the esophageal walls at the tumor level was not obstructed and there did not appear to be any fixation. Remaining lumen

was too small to admit the esophagoscope. Biopsy taken showed the esophageal mucosa to be partially intact and there was an occasional nest of cardio-esophageal glands. The stroma in most of the fragments was replaced by papillary adenocarcinoma, the cells of which were of the columnar type with granular cytoplasm and round to ovoid basophilic to vesicular nuclei which showed fairly frequent mitoses. The cells showed no significant secretion. Surrounding these zones of neoplasia there was a diffuse chronic inflammatory reaction. *Pathologic Diagnosis:* Adenocarcinoma of esophagus. A roentgenogram on September 7th showed irregular annular constriction of lower end of esophagus characteristic of ulcerative carcinoma (Fig. 16). Uranalysis and Kahn, negative.

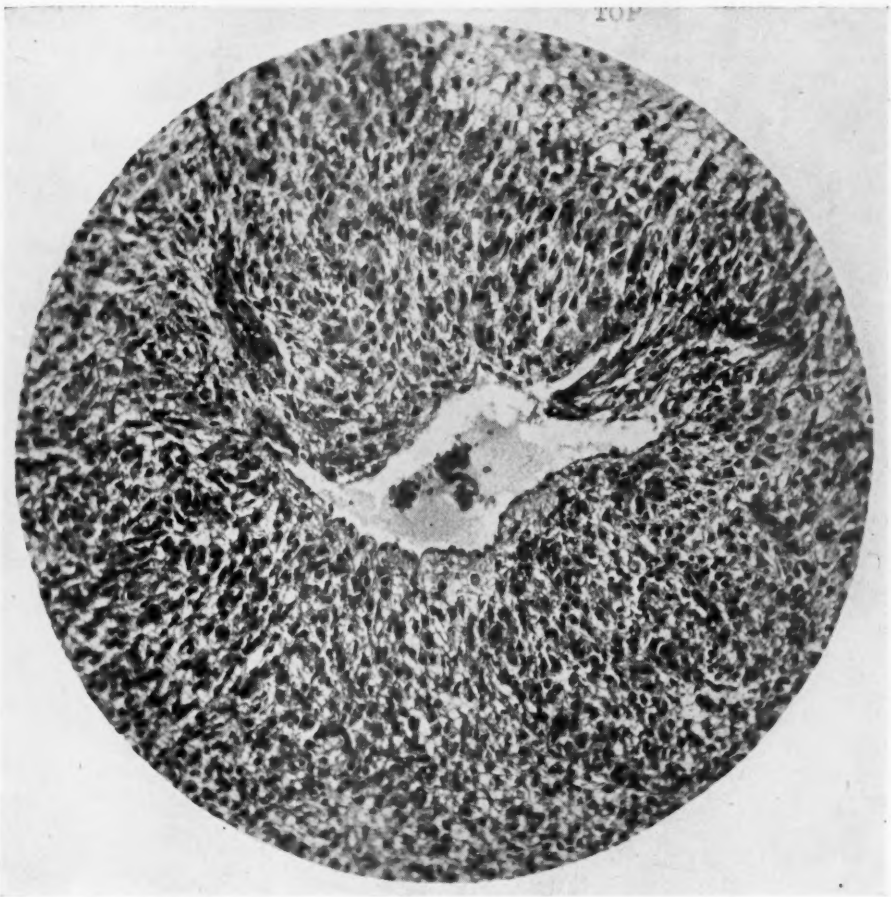

FIG. 15.—Case 2: Typical distribution around newly formed blood vessel. The neoplastic cells here show considerable vacuolation and centrally located vesicular nuclei are quite evident.

Operation.—September 18, 1944: The thorax was opened through bed of left 8th rib. Tumor of the lower 1.5 inches of the esophagus was palpable above the diaphragm and tumor of the cardia palpable through the diaphragm. There were no apparent metastatic lymph nodes in the mediastinum. Tumor was found to involve the cardia and fundus of the stomach. There was involvement of the diaphragm at the cardia. Crura of the diaphragm were divided well away from the mass back to the aorta, freeing the portion of diaphragm attached to the esophagus (Fig. 17). Incision was made over the esophagus up to the level of the pulmonary vein and the esophagus freed by sharp and

blunt dissection downward to the cardia. The spleen was removed for better exposure. Greater curvature of the stomach was freed and the lesser peritoneal cavity opened. The posterior surface of this cavity was found to be involved by infiltrating tumor so that the posterior peritoneum was dissected free down to the upper margin of the

FIG. 16.—Case 3: Roentgenogram showing obstruction of lower esophagus with extension of tumor into stomach.

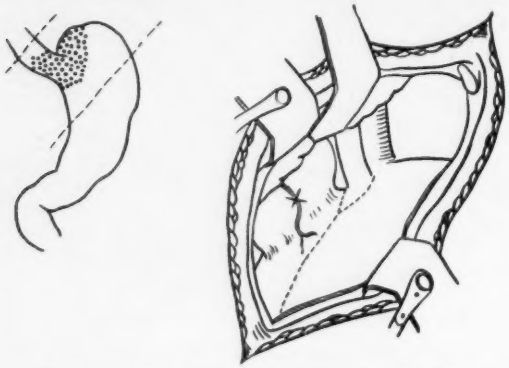

FIG. 17.—Case 3—Upper left: Diagram of tumor and lines of resection. Lower right: Line of incision in diaphragm with resection of diaphragm about the esophagus.

pancreas. Left gastric vessels were ligated close to the celiac axis retroperitoneally. Frozen section of tissue taken from region of celiac axis just at the upper border of the pancreas was reported as carcinoma. The stomach was divided at about its midportion. Esophagus was then divided about one inch above the tumor. The proximal end of the stomach was closed with two layers of inverting silk sutures; stomach was drawn up into the thorax and the apex of the greater curvature fixed to the endothoracic fascia with silk sutures. Posterior surface of the esophagus was sutured to

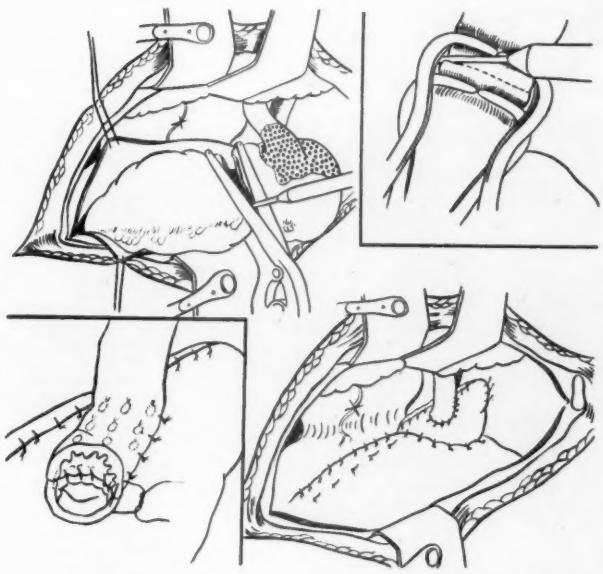

FIG. 18.—Case 3: Upper left: Division of stomach with cautery. Upper right: Division of esophagus with cautery. Lower left: Fixation of stomach and esophagus, and anastomosis. Lower right: Fixation of stomach and closure of diaphragm about stomach.

FIG. 19.—Case 3: Postoperative roentgenogram showing large portion of stomach above the diaphragm (indicated by dotted lines).

the anterior surface of the stomach for a distance of one inch. A one-inch incision was then made in the stomach and end-to-side anastomosis carried out between the esophagus and stomach. Diaphragm was closed with interrupted sutures of silk and the edges of

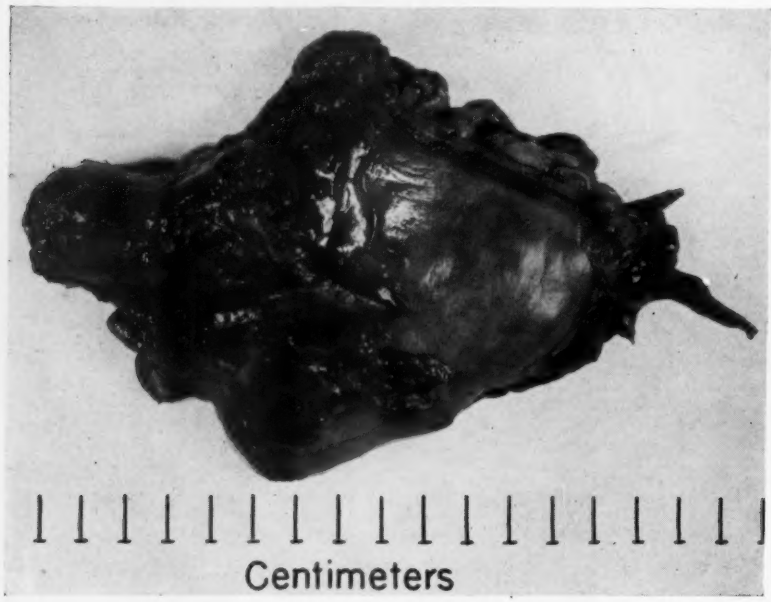

FIG. 20.—Case 3: Posterior view of specimen showing involved lymph nodes around the cardio-esophageal junction.

the diaphragm sutured to the stomach (Fig. 18). Fifty thousand units of penicillin were placed in the opening of the mediastinum. Lung was reëxpanded by the anesthetist and the thoracic wall closed in layers without drainage.

Postoperative course was excellent. One aspiration of bloody serous fluid in the

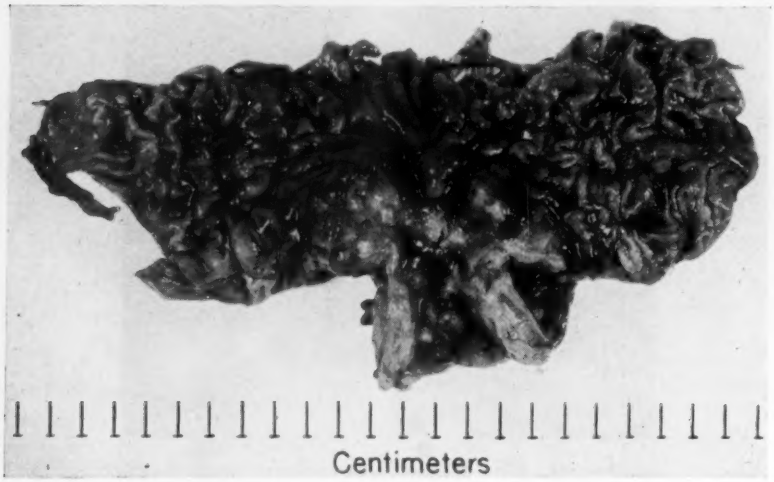

FIG. 21.—Case 3: Specimen opened showing greatly thickened esophageal wall with extension of the tumor into the cardia of the stomach. There is almost complete obstruction of the esophagus.

left chest was necessary. On October 20, esophagoscope was passed without difficulty. There were no signs of recurrence of tumor. Line of suture was seen where lumen was somewhat narrowed. There were no clinical symptoms of stricture and patient was eating normal diet without difficulty. At the time of his discharge from the hospital, November 8, 1944, he had gained considerable weight, was eating well, and had no

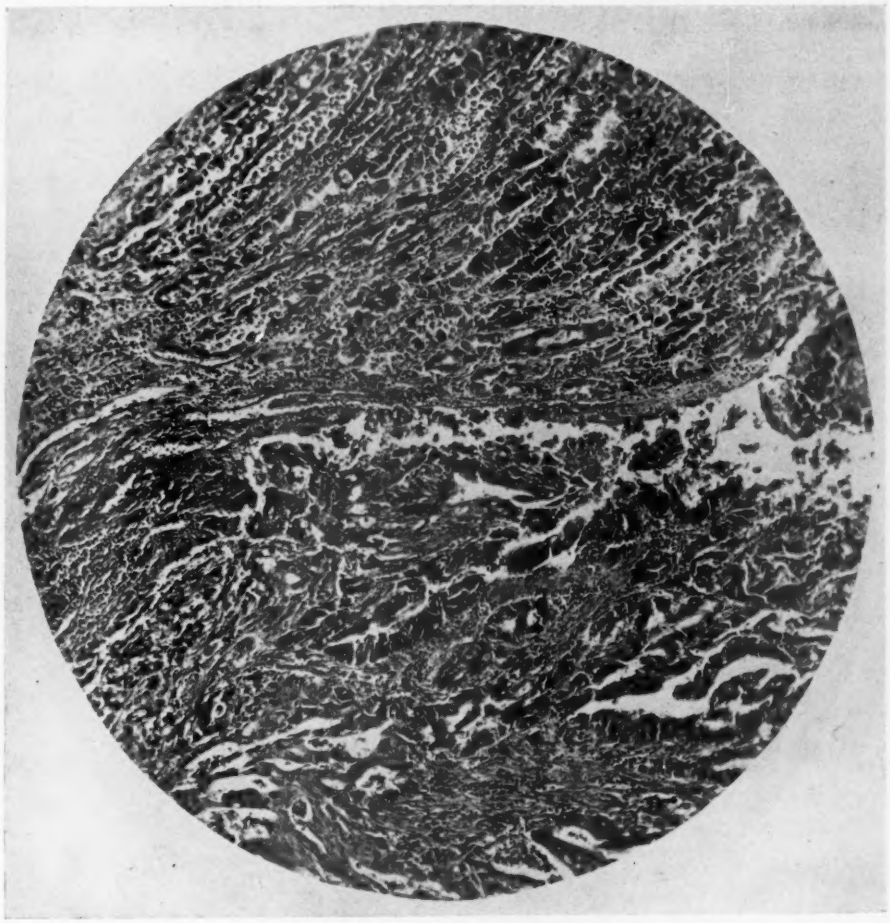

FIG. 22.—Case 3: Section of stomach showing extensive submucosal infiltration of the tumor.

symptoms. Fluoroscopic and film study of the esophagus and the stomach with barium swallowing, November 9, 1944, demonstrated no obstruction or filling defects. The left side of the diaphragm was located at the midportion of the stomach and did not move with respiration. Its lateral anterior and posterior portions were demonstrated and the opening for the stomach appeared adequate (Fig. 19).

Pathologic Report.—Capt. William S. Randall, M.C.: Normal spleen weighing 105 grams, which on section shows nothing of significance. With the spleen there is a 2.5 x 0.5 cm. soft lymph node, showing nothing of note on section. A separate specimen consists of 4 cm. of distal esophagus with a 9-cm. segment of stomach. A small portion of diaphragm is attached at the cardio-esophageal junction. Around the posterior portion of the specimen at the cardio-esophageal junction there are several small lymph nodes which are quite firm and seem to be replaced by tumor (Fig. 20). There is no evidence

of tumor along the resected esophageal portion or along the edges of the stomach. There is marked narrowing of the esophagus, particularly at the junction, the lumen measuring approximately 0.5 cm. Upon opening there is an 8-Mm. uninvolved portion of esophagus above the tumor and at one point a 1 x 0.5 cm. varix. The wall of the esophagus is 10–13 Mm. thick and the tumor is firm, fairly polypoid and extends mostly along the lesser curvature for 3 cm. while near the cardio-esophageal junction it almost encircles the lumen (Fig. 21).

FIG. 23.—Case 3: Section taken at cardio-esophageal junction showing large neoplastic glandular structures encroaching upon the "normal" esophageal mucosa.

Microscopic: Section through the esophageal portion of the specimen reveals a fairly large margin of uninvolved mucosa and muscularis. The portion of the involved esophagus shows extensive replacement of the submucosa and muscularis by infiltrating strands and nests of moderately differentiated glandular structures. The glands are lined with a stratified layer of columnar cells, the nuclei of which are generally round and moderately vesicular. A few mitotic figures are noted. There is a small amount of secretion within the lumen of the glandular structures. The general histology seems to indicate primary origin in the cardio-esophageal glands. Section of the stomach shows widespread submucosal infiltration of the tumor which involves a considerable

portion of the muscular coats (Figs. 22 and 23). There is rather diffuse dense fibrous reaction and here there is moderate chronic inflammation. Two of the several lymph nodes around the cardio-esophageal area show secondary adenocarcinoma, one of these being completely replaced. The spleen shows nothing of significance. *Pathologic Diagnoses:* Moderately differentiated adenocarcinoma arising in cardio-esophageal glands. Secondary adenocarcinoma in regional lymph nodes. Normal spleen.

CONCLUSIONS

1. The transthoracic approach to the upper abdomen widens the horizons of the surgery of gastric malignancy.

2. Three cases of transthoracic gastrectomy are reported, in one of which the cardia was anastomosed to the stump of the stomach, and in the other two esophagogastrostomy was carried out.

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A PLAN FOR THE SURGICAL MANAGEMENT OF GASTROJEJUNOCOLIC FISTULA*

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GASTROJEJUNOCOLIC FISTULA is a serious complication of peptic ulcer because the presence of such a communication between the stomach, jejunum and colon so profoundly influences the nutrition and health of the individual affected and because the treatment involves such a complicated and hazardous surgical procedure. That the risk in operations employed to treat patients with this condition is great is illustrated by the high mortality figures in various reports in the literature. Walters and Clagett reported a mortality of 32 per cent in 50 cases in which operation was carried out at the Mayo Clinic during the years 1928 to 1937 inclusive. More recently (1941), Gray and Sharpe, from the same clinic, reported 18 postoperative deaths in 49 cases, a mortality of 36.7 per cent. Allen reported a mortality of 25 per cent in eight cases, and Wilkie, a mortality of 40 per cent in his group of operated cases. Loewy recorded a mortality of 27 per cent in a series of 63 cases.

The cause of death in most cases has been peritonitis resulting from contamination during operation or from leakage from suture lines, or shock attending an extensive technical procedure. Pulmonary complications such as pneumonia, embolism and occasionally hemorrhage, cardiac or renal failure account for other postoperative fatalities.

Our interest in this serious problem has been stimulated by the high operative mortality reported in 1935 by Lahey and Swinton, in which the immediate operative mortality was 63 per cent in eight cases. Early in 1938 Dr. Lahey suggested a two-stage operative procedure, planned, we hoped, to avoid so high an operative risk. The first patient upon whom this plan was employed was successfully operated upon by the author in April, 1938. Since that date the operative method has been employed in 14 cases, with one death (which occurred after the first stage), a mortality of 7.1 per cent. This fatality occurred in the second case in which the operation was performed, in other words, during the period of development of certain technical steps in the operation, and we now believe that it probably represented an avoidable fatality. We propose in this communication to discuss briefly certain details of the problem of gastrojejunocolic fistula, to outline the operative procedure employed at present in the Lahey Clinic, and to report on 14 cases in which this method was used.

Gastrojejunocolic fistula most commonly occurs following operation for duodenal ulcer and in the majority of cases follows posterior gastroenterostomy. In our group of 14 cases, 12 patients had had posterior gastro-

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enterostomy and two had had an insufficient gastric resection, the original operation in all instances being undertaken for duodenal ulcer. Gastrocolic communication occasionally occurs from other causes but these cases are relatively uncommon. Fistulous communication between the stomach and colon may result from ulceration of malignancies arising either in the colon or stomach, but this, too, is not a frequent occurrence. Various other causes are given in the literature, such as peritoneal abscess and tuberculosis, and Bargen, *et al.*, reported one gastrocolic fistula secondary to ulcerative colitis. However, the majority of gastrocolic fistulae follow operation for duodenal ulcer and result from jejunal or gastrojejunal ulceration at the site of gastrojejunal anastomosis. Recurrent marginal ulcer always precedes the development of the fistulous communication and may occur years after the initial operation. In one case in this group (Case 13) the fistula developed 20 years after an insufficient gastric resection (Table I).

Atwater, Butt and Priestley stated that in a series of 40 cases studied, in 42 per cent the gastrojejunocolic fistula developed within a year after the original operation. In our own group of 14 cases, the interval between the initial operation and development of the fistulous communication was much longer.

Gastrojejunal or jejunal ulcer is a too frequent complication of gastro-enterostomy. Lahey and Swinton, in a study of the literature, reported a variation of incidence of 1.41 (Verbrugge) to 24 per cent (Strauss). Walters reported that ulceration occurred in three to four per cent of cases following gastro-enterostomy in the Mayo Clinic, whereas gastrojejunocolic fistula occurred in 23 of 169 cases of gastrojejunal ulcer, an incidence of 13.6 per cent. Allen reported an incidence of 14 per cent in 36 cases of gastrojejunal ulcer. Lahey, in a collective review, stated that in approximately 11 per cent of gastrojejunal ulcers, gastrojejunocolic fistula develops.

In view of the high incidence of gastrojejunocolic fistula following posterior gastro-enterostomy, it is evident that certain precautions are imperative to prevent this serious complication. Gastro-enterostomy is a valuable operation, but has a limited application and should be employed only when subtotal resection is definitely contraindicated because of the age of the patient, because of poor physical condition, and in the presence of certain technical difficulties that would make gastric resection hazardous. Furthermore, if resection is undertaken for ulcer, a considerable portion of the stomach must be removed (two-thirds or three-fourths). In two cases in which resection was inadequate in this group of 14 cases, recurrent ulcer and subsequently gastrojejunocolic fistula developed. Both of these patients had a retrocolic anastomosis and the colon lay directly upon the gastrojejunal anastomosis. The majority of the cases reported have occurred after posterior resection and posterior gastro-enterostomy. It is important that when posterior gastro-enterostomy is employed, the anastomosis should be made through an opening in the mesocolon placed near the base of the mesocolon

TABLE I

GASTROJEJUNOCOLIC FISTULA — 14 OPERATED CASES

Case	Age and Sex	Type of Operation Preceding Fistula	Period after 1st Operation Free of all Gastro-intestinal Symptoms	Duration of Symptoms Indicating Recur. Ulcer	Duration of Symptoms Indicating Fistula	Symptoms Accompanying Fistula upon Admission	Operation		Result
							1st Stage	2nd Stage	
1	43 M	Post. gastro-enterostomy, 1929	6 years	3.5 years	3 years	7–8 stools daily; undigested food in stool	Ileocolostomy 4–4–38	Resection 4–18–38	Well
2	34 M	Exclusion type resection, 3–11–35	1.5 years	2 years	1 week	Epigastric pain; nausea; vomiting; lost 15 pounds	Ileocolostomy, resection rt. colon, 12–28–38		Peritonitis; died 11th postop. day
3	54 M	Post. gastro-enterostomy, Oct. 1929	2 years	5 years	4 years	Epigastric pain; 10–20 stools daily; lost 20 pounds	Ileocolostomy 7–23–40	Resection 10–25–40	Well
4	60 M	Post. gastro-enterostomy, 1925	12 years	3 years	9 months	Epigastric pain; 6–10 stools daily; lost 40 pounds	Ileocolostomy; resection rt. colon, 6–2–41	Resection 8–7–41	Well
5	51 M	Post. gastro-enterostomy, Mar. 1939	6 months	7 months	2 years	Nausea; 8–10 stools daily; lost 25 pounds	Ileocolostomy 4–24–42	Resection 6–10–42	Well
6	29 M	Post. gastro-enterostomy, 1928	7 years	7 years	6 months	Flatulence; frequent watery stools; lost 15 pounds	Ileocolostomy 7–7–42	Resection 10–24–42	Well
7	53 M	Post. gastro-enterostomy, 1929	3 years	11 years	1 month	Flatulence, pain; frequent stools	Ileocolostomy 1–7–43	Not done	Fistula healed after first stage; well
8	49 M	Post. gastro-enterostomy, 1941	1 year	18 months	17 months	Pain; 7–20 stools daily; lost 30 pounds	Ileocolostomy 6–12–43	Resection 10–4–43	Well
9	52 M	Post. gastro-enterostomy, 1936	3 years	3 years	1 year	8–10 stools daily; lost 20 pounds	Ileocolostomy 12–14–43	Resection 3–6–44	Well
10	52 M	Post. gastro-enterostomy, 1936	7 years	6 months	6 months	Epigastric pain; severe diarrhea; lost 40 pounds	Ileocolostomy 1–29–44	Resection 9–6–44	Well
11	47 M	Post. gastro-enterostomy, 1928	12 years	3 years	1 year	Severe pain; diarrhea; lost 60 pounds; distention of abdomen	Ileocolostomy 5–29–44	Not done	Well 9–21–44; gained 21 pounds; barium enema failed to show fistula
12	48 M	Post. resection, 1939	5 years	6 months	6 weeks	Epigastric pain; severe diarrhea; lost 15 pounds	Ileocolostomy 6–9–44	Resection 9–24–44	Well
13	48 M	Gastro-enteros. 1922 Partial resec. 1924	9 years	11 years	3 months	Epigastric pain; diarrhea; weight loss	Ileocolostomy 8–2–44	Resection 9–27–44	Well
14	53 M	Post. gastro-enterostomy, 1933	11 years	3 months	1 month	Flatulence; anorexia; weight loss; diarrhea	Ileocolostomy 9–14–44		Well

and as far as possible from the colon. It is important to remember that evidence of increased colon irritability occurring in a patient with symptoms of recurrent ulcer indicates that the colon is adherent to the area of inflammation about the gastrojejunal anastomosis, and is evidence of impending perforation (Fig. 1). Operation should be advised and carried out as early as possible to prevent the serious complication of gastrojejunocolic fistula.

FIG. 1.—Impending gastrocolic fistula. Note the jejunal ulcer occurring after posterior gastro-enterostomy; the transverse colon adherent at ulcer area; and perforation of colon imminent, as proven at operation.

The symptoms of gastrojejunocolic fistula are characteristic and in the majority of the cases the diagnosis can be readily established. Recurrent ulcer distress occurring after operation, either gastro-enterostomy or resection, for peptic ulcer suggests gastrojejunal ulcer. The development of diarrhea with weight loss is strongly presumptive evidence of gastrojejunocolic fistula. Pain at first may be severe and with perforation into the colon may subside but in the majority of our cases it continued as epigastric distress. A history of belching of foul gas or vomiting of foul stomach

contents may be obtained in many cases. The stools are watery, frequent (6 to 20 per day), and often contain undigested food particles. Weight loss is often extreme and in two cases was as much as 40 pounds within a few months. In addition to emaciation, dehydration, nutritional edema, hypoproteinemia, anemia and serious states of vitamin deficiencies are often encountered.

Roentgenologic examination readily confirms the clinical diagnosis. Positive roentgenographic findings were present in all of our 14 cases. The fistulous communication is usually easily visualized by barium enema (Figs. 2 and 3), and under the fluoroscope the barium mixture can be seen pouring into the stomach from the colon. The diagnosis was established in the majority of our cases by roentgenologic examination after a barium enema; in four instances the fistula was first visualized following the ingestion of a barium meal (Fig. 4).

The majority of gastrocolic fistulae occur in men, and in our series all patients were males. This is the experience of other writers upon this subject. Walters reported that only one patient in his group of 50 cases was a woman.

In most of the cases of gastrojejunocolic fistula reported by other writers, the patients were between 40 and 60 years of age. A similar age distribution is noted in our series. Only two patients were less than 40 years of age, the youngest being 29 years and the oldest, 60 years.

The treatment of gastrojejunocolic fistula is purely surgical and the surgical management of a large gastrojejunocolic fistula is technically difficult and often accompanied by considerable operative risk. The generally poor condition of these patients, the stage of malnutrition, the marked alteration in protein and blood chemistry findings make any extensive operative procedure, with measures to improve these states, entirely unsafe and, consequently, unwise. Most of these patients have had repeated abdominal operations, which have resulted in extensive adhesions and distortion of abdominal anatomy. This makes for time-consuming dissection to identify structures and establish anatomic relations before any restorative operative procedure can be carried out.

In an endeavor to avoid the high operative risk in these cases, numerous operative procedures have been suggested and employed by different surgeons. Experience has demonstrated that in order to prevent the recurrence of ulceration in any complicated ulcer case, a radical subtotal resection of the stomach should be employed and that an ulcer is less likely to recur after resection. It is evident, therefore, that in addition to excision of the fistulous tract, a radical subtotal gastrectomy should be included in the operative plan. However, an extensive block dissection of the fistulous tract in addition to a subtotal gastrectomy undertaken in one stage is entirely too hazardous to employ and would certainly result in a high percentage of fatalities. An operation designed to excise the fistulous tract and disconnect

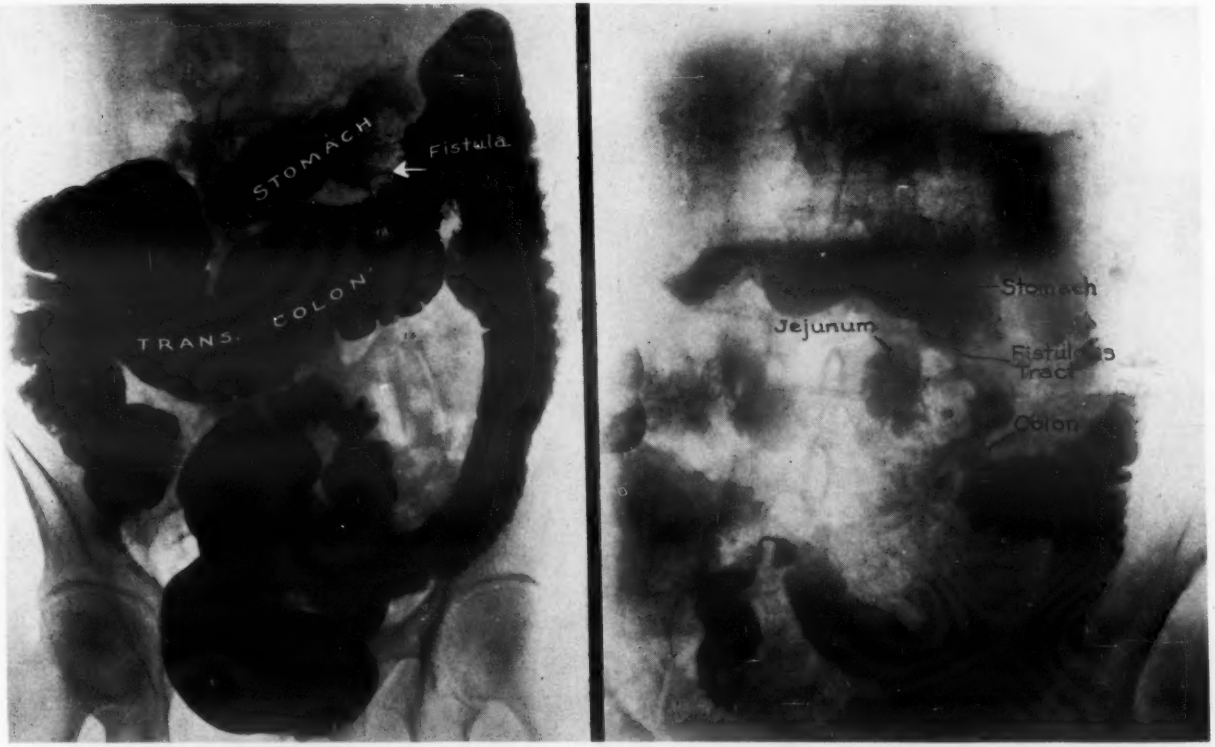

FIG. 2

FIG. 3

FIG. 2.—Roentgenogram taken after a barium enema, demonstrating a gastrojejunocolic fistula. Barium sulfate, given by enema, partially fills the stomach. Note the fistulous communication and also the constricted area in the transverse colon at point of the fistula (Case 9).

FIG. 3.—Gastrojejunocolic fistula. Barium sulfate given by enema is shown to enter the stomach and jejunum from the colon through the fistulous communication.

the stomach, jejunum and colon is undoubtedly the simplest form of surgical approach, but reestablishment of normal gastro-intestinal continuity will result in recurrent ulcers in a large group of cases, and it is not to be recommended in the majority of cases. Furthermore, the induration and extent of the inflammatory exudate may preclude any possibility of closing the rent in the colon or jejunum, and disconnection may compel the surgeon to proceed with extensive resection of the involved colon and jejunum, which immediately places the operation at a high risk level.

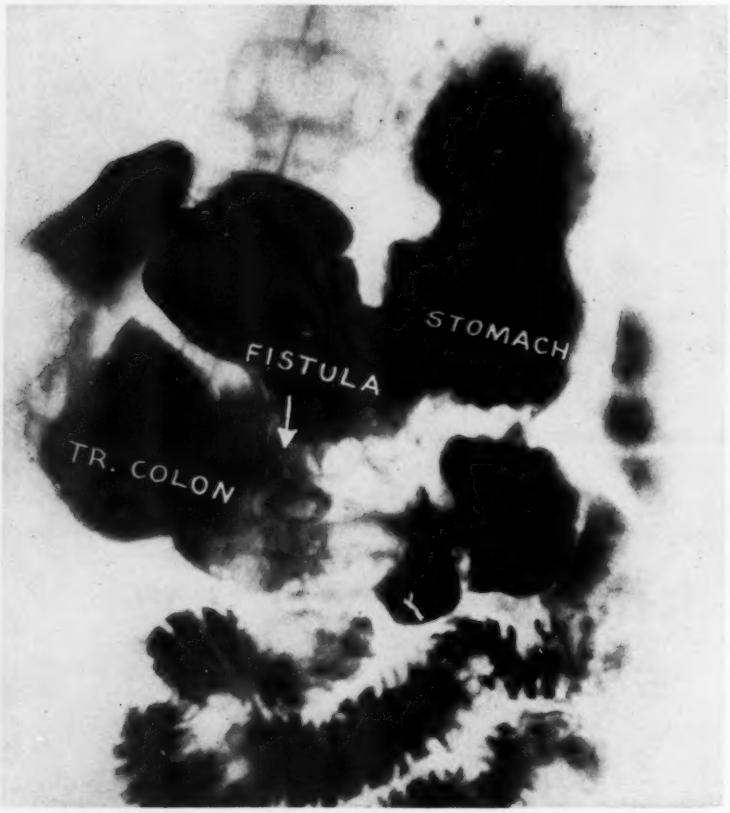

FIG. 4.—Roentgenogram taken after a barium meal, demonstrating a gastro-jejunocolic fistula. The barium has passed readily from the stomach into the transverse colon and into the jejunum. Note the area of spasm in the colon (Case 5).

Simple excision of the fistulous tract and restoration of gastro-intestinal continuity has been most often employed in groups of cases reported and it is with this type of operation that the mortality has ranged from 25 to 63 per cent. In addition, the tendency to recurrent ulceration profoundly influences the type of operation that should be employed for gastrojejunocolic fistula and a simple disconnecting operation, therefore, is not to be recommended because of the high recurrence rate. In Walter's series of 50 cases, most patients had a simple disconnecting operation and only nine had

an additional subtotal resection, yet the mortality in this group was 32 per cent. Finsterer has preferred a one-stage operation for gastrojejunocolic fistula, but employed a two-stage operation if simple closure of the colonic fistula was impossible. He reported operation in 13 cases, with five deaths, a mortality of 38.4 per cent.

Because of the poor nutritional condition of patients with gastrojejunocolic fistula and because the operation in most instances involves long and tedious dissection, a two-stage procedure is to be recommended.

Pfeiffer,[9] in May, 1938, presented before the American Surgical Association an operative method employing a preliminary colostomy proximal to the fistula as a first-stage procedure. In 1941, he reported[10] a series of collected cases in which this plan had been employed; ten patients had gastric resection in the second stage and five had simple excision of the fistula and restoration. One death resulted in this group, a mortality of 6.6 per cent.

This operation by Pfeiffer apparently reduces the operative hazard greatly and his mortality is the lowest yet reported in any operation designed to treat the serious complication of peptic ulcer. This method, however, presents certain technical problems which tend to complicate the operation and are, to a certain extent, undesirable. During the second stage, any extensive block dissection of the fistulous communication with additional gastric resection has to be carried out in the presence of a right colon fixed to the abdominal wall by virtue of the established colostomy and, also, in the presence of fecal contamination of the abdominal skin surface. The colon fixation adds to the difficulty of mobilizing the transverse colon, duodenum and pylorus in event of gastric resection. Soiling of the abdominal wall by a draining colostomy increases the hazards of abdominal wound and peritoneal infection. Moreover, on completion of the second stage, whatever it may be, the surgeon still has the colostomy opening to close, which adds to the extent of operation.

The operative procedure for treatment of gastrojejunocolic fistula employed at present at the Lahey Clinic, according to the plan suggested by Doctor Lahey, was first used in April, 1938. Since that date we have used this method in 14 cases, with one death, a mortality of 7.1 per cent. This operative plan consists of a two-stage procedure and employs the principle of block excision of the section of jejunum and colon involved, plus gastric resection. The first stage of the operation is designed to divert small intestinal and colonic contents from regurgitating into the stomach and jejunum. This is accomplished readily by dividing the terminal ileum and performing an ileocolostomy between the terminal ileum and descending colon. Small intestinal and right colon contents are thus emptied into the descending colon and cannot reenter the stomach and jejunum. The toxic and irritating effects of such regurgitation are thus avoided, and these patients have tended to improve in nutrition, gain in weight and in most

instances have complete cessation of diarrhea. If the diarrhea does not completely cease, the number of stools per day in all cases is greatly reduced. It is important that the first stage of the operation be as simple as possible, because it is at this stage that the patient's condition is at its poorest. Our single death occurred in the second patient operated upon, and after the first stage during which the right colon was removed in addition to ileocolostomy, in

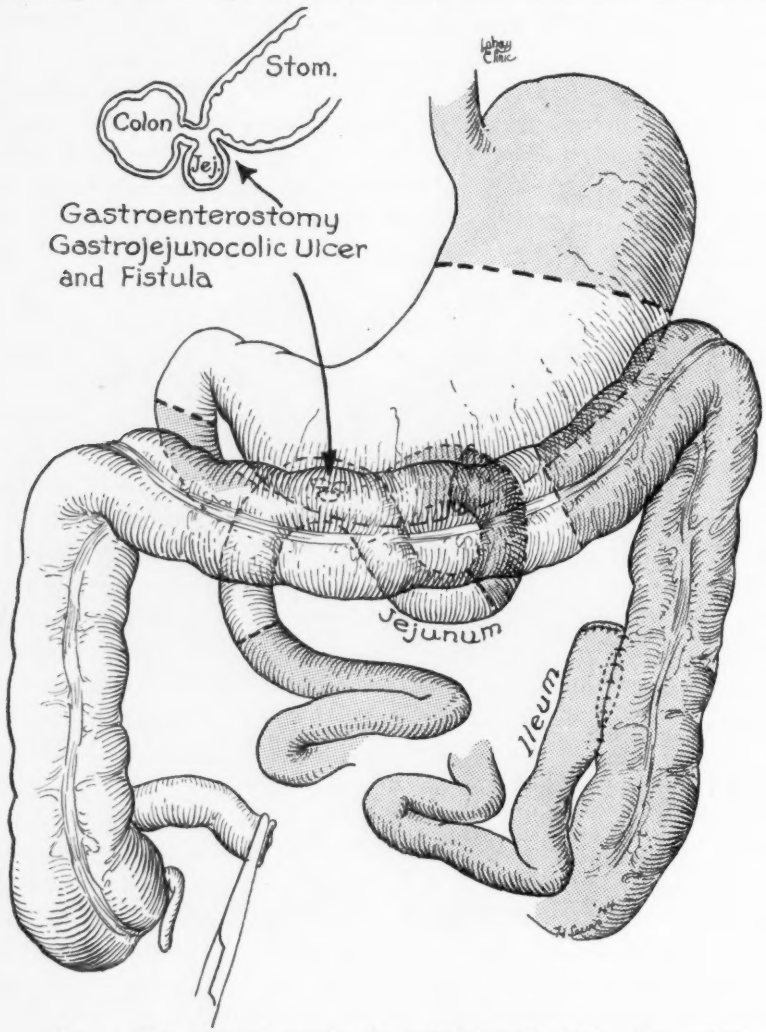

FIG. 5.—First stage of operation for gastrojejunocolic fistula. The terminal ileum has been divided, the proximal end of ileum has been closed by inversion and a side-to-side anastomosis between the terminal ileum and descending colon has been established. The distal end of divided ileum is likewise closed by inversion and dropped back into the abdomen. The light segments indicate the portions of stomach, colon and jejunum which are to be removed at the second operation.

the hope of simplifying the second stage of the operation. The right colectomy should not be undertaken during the first stage because it materially adds to the technical procedure of the first stage and increases the risk at a dangerous period of the patient's nutritional imbalance.

The first stage of operation for gastrojejunocolic fistula (Fig. 5) is as follows: The abdomen is opened through a left rectus incision. The involved areas of colon, jejunum and stomach are inspected and gently palpated, care being exercised to avoid separating adhesions in this area, which might possibly lead to leakage about the inflamed fistulous tract. The terminal ileum is identified and divided about six inches from the ileocecal valve, the mesentery being split sufficiently to permit approximation of the terminal

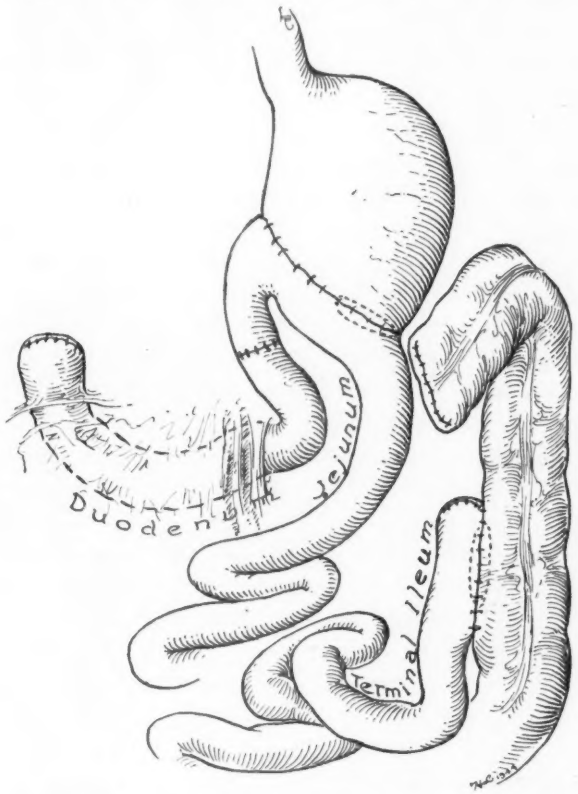

FIG. 6.—Second stage of operation for gastrojejunocolic fistula. Drawing illustrates the completed operation. Note that the right colon and transverse colon to a point past the fistula, together with the portion of the jejunum involved with ulcer, have been resected. A gastric resection completes the operation.

ileum to the descending colon. The divided ends of the ileum are closed by inversion with layered sutures of catgut and silk. A side-to-side anastomosis of ileum to descending colon is then established and the abdomen closed in layers.

When the method was first used, the second stage was carried out in about two weeks after the first stage. However, it early became evident that a longer interval should elapse between stages in order that the patient's nutrition and general condition could improve. It is now an established practice to send these patients home for a period of two or three months before completing the operation by the second-stage procedure. A diet high

in vitamins, protein and calories is given during this interval. Marked gain in weight is usual and one patient gained as much as 40 pounds between stages. Marked improvement in general condition was noted in all cases.

The second and final stage of the operation for gastrojejunocolic fistula is as follows (Fig. 6): The abdomen is again opened through a left rectus incision which extends from the costal margin to a level below the umbilicus. The cecum, right colon and transverse colon are mobilized to a point distal to the colonic fistula. All mesenteric attachments are divided. The transverse colon beyond the fistula is then divided with the actual cautery between clamps, and the end of the distal portion of the transverse colon is inverted with catgut sutures, which are reinforced with interrupted silk sutures. The colon and attached stomach may then be turned forward and the involved loop of jejunum is readily visualized and likewise resected. A high resection of the stomach after mobilization and division of its attachment completes the block excision of the fistulous tract and involved viscera. An end-to-end jejunal anastomosis is carried out before completing the gastrojejunal anastomosis (Fig. 7). The operation is extensive, but not nearly so formidable as it would appear. Mobilization and division of the colon permits easier mobilization of the stomach and ready resection of the jejunum. All of these cases have been operated upon without shock, and the convalescence has been remarkably uneventful after such an extensive resection (Fig. 8).

Our experience with two cases has been of especial interest. One patient (Case 11), 47 years of age, who had had definite symptoms of gastrojejunocolic fistula for a period of a year, during which time he had lost 60 pounds in weight, reported immediate improvement following the first-stage operation of ileocolostomy. Four months after operation he has gained 21 pounds, diarrhea has completely ceased and he has been completely asymptomatic. Repeated examinations with barium enema have failed to show any colonic communication even though this could be readily demonstrated by barium enema before operation. Another patient (Case 7), 53 years of age, who had symptoms of gastrocolic fistula of one month's duration and who had indisputable roentgenologic evidence of fistulous communication, apparently has also obtained healing following the first stage. Barium enema has failed to show colonic communication and to date, nearly two years following the first-stage procedure, he is quite well. It should be emphasized, however, that the great majority of patients with gastrojejunocolic fistula will require the second-stage gastric resection and block excision of the fistulous tract in order to be completely freed of all symptoms. In view of these two cases in which the fistula closed after the first stage, with marked improvement in nutrition and cessation of diarrhea and distress, roentgenologic examination should again be repeated in every case before the second stage of the operative procedure is carried out. Should examination fail to reveal the colonic fistula, no harm can result from deferring the second stage, provided the patient improves in health and provided repeated examinations fail to show the fistula.

FIG. 7.—Specimen, gastrojejunocolic fistula, removed at second stage of operation.
(a) The colon has been opened and a large fistulous orifice into the colon is demonstrated.
(b) The gastric and jejunal mucosal surfaces are shown, illustrating the site of the fistula which opens into the colon. Note that a jejunal ulcer is present and that the fistula has occurred at the margin of the gastrojejunal anastomosis.

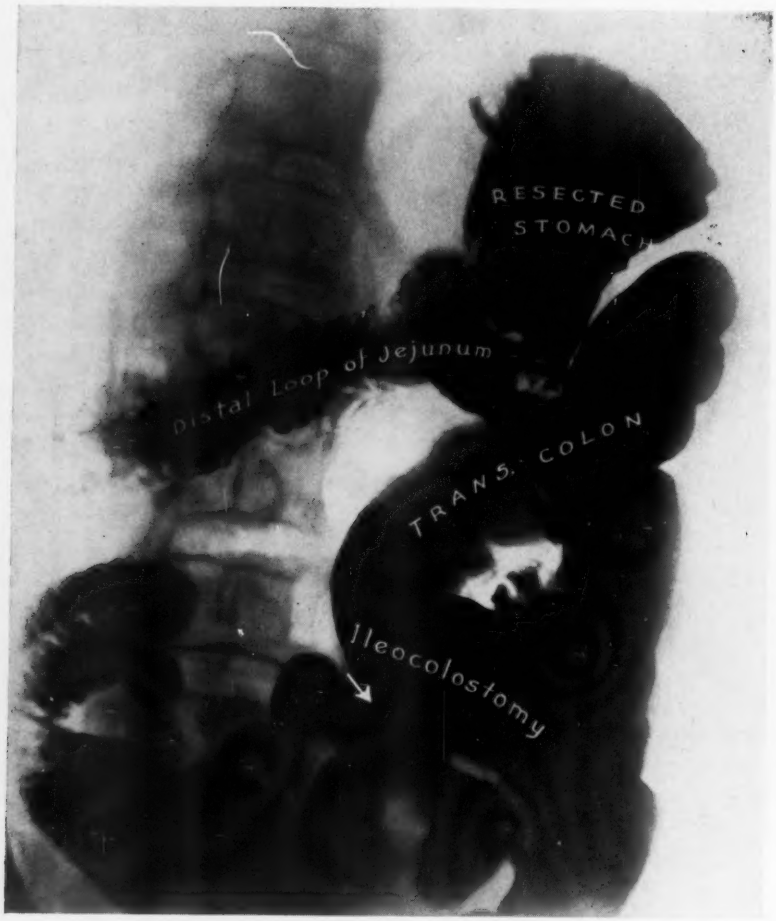

FIG. 8.—Roentgenogram taken after second-stage operation for gastrojejunocolic fistula. Barium sulfate mixture was given by mouth and also by enema. Note the resected stomach and also the remaining colon and the anastomosis between the terminal ileum and the colon.

SUMMARY

Gastrojejunocolic fistula is a serious complication of peptic ulcer and any surgical method of treatment will require an extensive operative procedure which may be extremely hazardous.

Gastrojejunocolic fistula follows gastrojejunal ulcer and occurs in about 11 to 14 per cent of such recurrent ulcers.

Surgical treatment of this condition should consist of excision of the fistulous tract combined with a high gastric resection.

A two-stage operative procedure is to be recommended. A two-stage method employed in the Lahey Clinic is described. Results in 14 cases in which the operation has been employed are briefly reported.

The immediate operative mortality in the group of 14 patients was 7.1 per cent.

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DISCUSSION.—DR. J. SHELTON HORSLEY, Richmond, Va.: Doctor Rienhoff is to be congratulated on the results he has obtained and the excellent way in which his patients have been followed.

For a good many years I have been using a modification of the Billroth-I type of partial gastrectomy, which I have published several times. Of course, no one type of partial gastrectomy is always applicable and I occasionally use a type of Billroth-II, as the Hofmeister or Pólya, such as Doctor Rienhoff describes.

Peptic ulcer of the duodenum is usually cured by medical treatment, but in the event that it cannot be so cured and it becomes a surgical case, the lesion is often in the posterior wall of the duodenum and has penetrated into the head of the pancreas. At least, this has been my experience. One of the chief difficulties in such cases is the treatment of the stump of the duodenum. If the ulcer is removed the stump of the duodenum is short and difficult to close. If a little shelf of the posterior wall of the duodenum is dissected from the pancreas, the stump of the stomach can be brought over and united to the duodenum with a series of interrupted mattress sutures of chromic catgut. All of these are placed before any one is tied, and if before tying them the Payr clamp is removed from the stomach and an incision of about 1 to 1.5 inches is made in the anterior wall of the duodenum, the stomach can be puckered and a straight end-to-end anastomosis may be made. Before tying these sutures, a tag of omentum is brought over the raw surface of the pancreas behind the sutures and sutured to this surface and to the upper border of the pancreas. This tends to reinforce the posterior portion of the anastomosis and covers the raw surface of the pancreas. The rest of the operation is performed as described elsewhere. The posterior margin of

the stump of the stomach is then sutured to the posterior margin of the shelf of the duodenum with a continuous lock-stitch of chromic catgut.

The value of giving proteins as soon as possible after operation is being emphasized more and more. After the posterior portion of the anastomosis has been completed, a forceps is passed through the stump of the stomach and pushed through the anterior wall of the stomach at a point about four inches from the margin of the stump. Two small catheters with additional perforations are drawn through, one for about 3.5 inches and the other for almost its entire length, leaving only about four inches of it outside the stomach. Each catheter is sutured to the gastric wall separately with fine chromic catgut and a purse-string suture is then placed around both. The short end drawn through is left in the stomach and the long end is carried through the duodenum with long forceps and into the jejunum. The anterior portion of the anastomosis is then resumed and the two catheters are brought through a stab wound to the left of the incision, or through the upper portion of the abdominal wound. The anterior wall of the stomach is sutured to the parietal peritoneum and a tag of omentum is drawn around the catheters for further protection. Thus, the stomach is kept empty without the discomfort that an indwelling nasal tube would bring, while through the other catheter a formula of proteins for the jejunum can be introduced within 48 hours after operation.

There are, to be sure, some recurrences of duodenal ulcer or anastomotic ulcer which is duodenal after this type of operation, but they usually can be treated medically with success. I have had to operate upon only one case of recurrent ulcer after this type of gastrectomy, and then I did a gastro-enterostomy, and the patient obtained perfect relief. After a Billroth-II type of operation, however, the prospect of a jejunal ulcer hangs over the patient; it may not occur for many years. And a jejunal ulcer is a very different problem from recurrent duodenal ulcer. It almost always requires a difficult and serious operation, and even then the conditions that produce a jejunal ulcer are not materially altered.

The criterion as to the presence of free hydrochloric acid in the stomach after a type of Billroth-II operation is often fallacious. The duodenal contents, in which the chief alkaline factor is pancreatic juice, may flow into the stomach to such an extent as to neutralize the free acid secreted by the remaining part of the stomach. There is, too, the natural tendency for a deficit in the function of an organ to be replaced by hypertrophy and hyperplasia of the organ. Thus, it is well known that large portions of the kidney or the liver may be experimentally removed if done at intervals, and the remaining portion will usually hypertrophy sufficiently to carry on vital function, which would not occur were too much of these organs removed at one time. This seems to be true with the stomach; after removal of large amounts, the remaining portion hypertrophies and a much more free secretion of acid in the gastric juice results. The small intestinal tract increases in sensitivity to gastric acid from the duodenum down. As physiologists have shown, there is a natural regurgitation of duodenal contents into the stomach during the normal process of digestion, and one cause of a peptic ulcer is spasm of the pyloric portion of the stomach which prevents the normal regurgitation of duodenal contents. After removal of the pyloric end of the stomach there is nothing to obstruct a full amount of regurgitation of duodenal contests.

As for gastrojejunocolic fistula, the cause of such a fistula is excessive hydrochloric acid in the gastric juice. This is distinctly antiseptic and renders this type of fistula quite different from an ordinary fistula in aseptic colon. Consequently, it would seem that extensive resection of the colon in such a condition is unnecessary; even though there may be some ulceration in the colon, if the irritating cause of this ulceration—high acid content of the gastric juice—is removed, the ulcer will doubtless heal.

DR. R. L. SANDERS, Memphis, Tenn.: I shall confine my remarks to Doctor Rienhoff's subject. I am of his opinion that a study of cases in private practice should give us an idea of where we stand after 25 years of dealing with stomach problems. With this objective, we recently made a study of our cases of gastric resection for stomach and duodenal ulcer and reported the findings at the meeting of the Western Surgical Association.

This study covered a period of 26 years (1918–1944), and included 1,218 private ulcer cases, divided into two groups, from 1918 through 1931, and from 1932 to the

present time. In the first group we did 35 pyloroplasties, 125 gastro-enterostomies and three resections. In the second group there were 14 pyloroplasties, 58 gastro-enterostomies and 101 resections. We have not done a pyloroplasty in five years; since 1940 the number of resections has increased 25 per cent while the number of gastro-enterostomies has diminished correspondingly. At the present time, three-fourths of our operations for primary duodenal ulcer are resections. Thus, during the past decade we have swung definitely from palliative to radical treatment of duodenal ulcer.

We also agree with Dr. Rienhoff that, if one takes out the ulcer-bearing zone, the result will be satisfactory. In the average case we do not remove more than 65 per cent of the stomach. With this operation we have found that 80 per cent of patients are completely relieved and an additional 10 per cent partially relieved. The remainder have had symptoms and clinical evidence of recurrence, or have had some complication which has obscured the result of the operation.

When one considers this partially relieved group one wonders if the pendulum has swung too far toward resection. These patients no longer have intractable pain, but still have a little nausea and perhaps some vomiting, they are weak and anemic and cannot gain weight. The question is even more serious concerning the unrelieved group. Perhaps a gastro-enterostomy would have been the better procedure. On the other hand, had a gastro-enterostomy been done, a resection might ultimately have become necessary. Some patients apparently have what we call the "ulcer diathesis," and no matter what is done, either medically or surgically, they remain unchanged. They are the ulcer type and, despite even radical resection, are candidates for further trouble. We do not yet have the answer to the problem in these cases, but until we do it is well to remember that, although we may expect fewer recurrent ulcers after resection, gastro-enterostomy is still the best operation for a good number of patients.

Dr. Willard H. Parsons, Vicksburg, Miss.: I desire to add three additional case reports to those presented by Colonel Griswold. Each was operated upon by a trans-abdominal approach, and I am inclined to believe that general surgeons, untrained in the refinements of thoracic surgical technic, will find this approach preferable to the transthoracic route. Thoracic surgeons may find the transthoracic as safe as the abdominal route, however, and in their hands such a procedure may be superior.

The first patient, a woman past the age of 50, was found, on study and at surgery, to have a benign gastric ulcer somewhat larger than is usually encountered. The case is of interest, however, because as shown (slide) there is demonstrated by tissue section one of the larger major bleeding points at the base of the ulcer. A thrombotic plug in one of the major arteries is shown, and the bleeding from this vessel was controlled only by gastrectomy.

The next patient, a woman, age 38, came to the Clinic because of serious gastric hemorrhage of such severity that the hemoglobin level was 40 per cent; erythrocytes 2,050,000. The roentgenograms ultimately revealed a very small prepyloric lesion. Radical subtotal gastrectomy was done with inclusion of great omentum, and microscopic section showed a rather small sarcoma of the stomach (slide). The sarcoma was obviously cellular and contained a number of vascular spaces that might tempt one to place this tumor in some special classification. Ewing, however, holds that vascular spaces of this type do not warrant bizarre classification of the tumor. The slide also demonstrates over the tumor the site of an ulcer which had healed under medical management.

The final patient to be reported was a man, age 70, who had developed symptoms referable to the stomach nine months prior to registration at the Clinic. Ultimately, a diagnosis of polyposis of the stomach was established and subtotal gastrectomy was performed (slides). It is unusual for polypoid proliferation to so closely follow the lines of the mucosal rugae that there are no true isolated polypoid tumors, but rather polypoid hyperplasia of the entire mucosa. The microscopic section shows the rather curious cystic hyperplasia of mucosal glands which occurs in polyposis of the stomach.

Dr. Charles C. Green, Houston, Texas: I should like to comment on Col. Griswold's paper. Two years ago I heard an excellent presentation on this subject read before the Texas Surgical Society by Major Coleman, one of our guests today, and he showed a wonderful motion picture of his surgical technic of the transpleural approach

to lesions of the upper abdomen. I am glad to hear Col. Griswold recommend the resection of the tenth rib. I have never done this, but I believe it will give a more flexible opening and an easy approach. I think it is one of the greatest advances in upper abdominal surgery.

Dr. Frank H. Lahey, Boston, Mass.: From my point of view it is safer to make the exploration to determine operability in many lesions situated very low in the esophagus through the abdomen rather than through the pleural cavity. A small incision through the abdomen permits the patient to get up and around in a day or two and often more readily settles the question of operability than does chest exploration. If one chooses to operate in two stages for lesions low in the esophagus, the stomach can, by the abdominal route, then be devascularized, and the omentum can be taken off. The omentum so often contains metastases in these cases that omentumectomy is worth doing. In addition, the spleen can be removed when the omentum is taken off abdominally, which makes for easier handling, wider removal, and, thus, increased radicalness when the second stage is done through the chest. Furthermore, removal of some of the high gastric lesions can be done more safely from below by a total gastrectomy, than from above, as transthoracic resection. We have now done more than 90 total gastrectomies, and the mortality, certainly in the last 25, is down around 10 per cent.

Some time ago we suggested that in all cases of gastric cancer, the stomach be irrigated preoperatively with 0.7 per cent hydrochloric acid, because by this means the bacterial count in the gastric contents can be almost entirely eliminated prior to operation.

With regard to Doctor Rienhoff's paper on peptic ulcer, I have just sent an editorial to one of the surgical journals on this subject in which I stated that the mortality of subtotal gastrectomy for ulcer today has resolved itself, in our hands, almost solely to the proximity of the ulcer to the common duct. Peritonitis as a mortality factor, together with pneumonia, has been practically eliminated.

We feel very strongly that as we have increased our experience with subtotal gastrectomy in patients with duodenal ulcer, we have removed more and more ulcers and the results have been better; we feel very strongly that the Finsterer operation by exclusion is a bad operation. In it we have seen more recurrent gastrojejunal ulcers in the gastric stump than have occurred following subtotal gastrectomy in which all of the pylorus and prepyloric region is removed. We feel strongly, likewise, that the results have been better in subtotal gastrectomy when we have taken out that portion of the duodenum containing the ulcer.

I would like to submit a plan, which I have also just sent for publication, which makes the removal of these ulcers easier; that is, a T-tube is inserted into the common duct, the sphincter of Oddi is dilated, and the tube is passed through the duct into the duodenum. It is a great comfort to know where the sphincter of Oddi is. If the tube protrudes through it, you can put your finger on it, know the level at which it enters, and you know how much duodenal stump there is left. You can also be sure of the location of the duct behind the duodenum as it passes through the indurated bed of the pancreas.

As to the amount of stomach to be removed, everyone has to settle that for himself. I do not think that is as important as removal of the ulcer. We have seen enough cases in which the ulcer has been left behind, in which a jejunal ulcer has occurred in the stump and in which secondary removal of the ulcer has resulted in healing of the gastrojejunal ulcer in the stump of the stomach, that we are convinced that leaving ulcers is undesirable.

We realize that there are occasional ulcers which are so indurated and so scarred that no plan exists whereby they can be removed safely, and we realize that in these cases a two-stage operation, such as the Finsterer resection by exclusion or a high gastroenterostomy, with a deliberate plan for a second-stage removal of the ulcer when it has healed, has a real place.

Colonel I. Mims Gage, Atlanta, Ga.: The edited transcript was not received in time for publication. If it is received before the "Transactions of the Southern Surgical Association" is published, it will appear therein.

DR. DERYL HART, Durham, N. C.: This discussion will be limited to the question of treatment of severe hemorrhages from ulcers. There is a fairly widespread opinion that operation in the presence of a low hemoglobin due to repeated severe hemorrhage is followed by an almost prohibitively high mortality. Our experience has been that we can delay operation, use repeated transfusions, and have the hemorrhages stop in most cases, with a very low mortality in the nonoperative cases. As a result of this method of treatment, however, patients coming to operation have been the poorest surgical risks, but by the use of large quantities of blood (1500 to 4000 cc.) immediately before and during operation the mortality in the operative cases has also been kept low.

Of a total of 1318 ulcer patients admitted to the hospital, 275 (21 per cent) have come in with bleeding at time of admission; 79 had an hemoglobin below 50 per cent. Of this latter group 66 were treated by non-operative methods with one death, a mortality of 1.5 per cent. Thirteen continued to bleed and were operated upon, with one death, giving a mortality of 7.7 per cent in the operative group. The one death following operation was in a patient with an ulcer low down (at or below the ampulla of Vater) in the duodenum, making resection impossible. An exclusion operation was performed, bleeding continued from the ulcer, and death was due to hemorrhage. The mortality for the entire group of patients whose hemoglobin was below 50 per cent was 2.5 per cent.

From this experience we feel that patients with a bleeding ulcer should be treated first by nonoperative measures. In the small group where such treatment fails, operation can be performed with relative safety if large quantities of blood are given before and during operation. With such a regimen the total mortality has been lower than would have been likely had a high percentage been treated surgically soon after admission.

COLONEL R. A. GRISWOLD, M.C., Washington, D. C. (closing): With regard to Doctor Lahey's remarks, we have not irrigated the stomach in cases where there was no stasis; however, we have administered dilute hydrochloric acid either by mouth or tube in those cases with achlorhydria. I cannot agree with Doctor Lahey on the danger of the thoracic approach. The thoracic surgeons have shown us that the chest can be entered with the same impunity as the abdomen, if proper attention is paid to respiratory physiology. In tumors of the upper stomach and lower esophagus, the operation is certainly easier with the lesion directly in the middle of the field rather than up under the dome of the diaphragm. If necessary, total gastrectomy may be carried out by the thoracic approach as well as by abdominal route.

DR. WILLIAM F. RIENHOFF, JR., Baltimore, Md. (closing): I have enjoyed the discussions of Doctors Horsley, Sanders and Lahey very much indeed. It is my opinion that the antecolic gastrojejunostomy or anterior Pólya type of anastomosis is to be preferred rather than the Billroth-I as suggested by Doctor Horsley; the reasons being (1) shunting the gastric contents away from the duodenum insures more prompt healing of an ulcer in this region; and (2) neutralization is more complete when jejunal contents are constantly irrigating the remaining gastric pouch. I agree with Doctor Sanders that there is a definite group of cases, *e.g.*, older individuals with a scarred and stenotic pylorus, in which a simple posterior gastro-enterostomy is the operation of choice.

Doctor Lahey's point about performing a total gastrectomy abdominally instead of transthoracically is interesting. Doctor Longmire, our resident surgeon, has had a most unusual series of cases with carcinoma of the stomach in which he has performed a total gastrectomy intra-abdominally without a death. Except in instances in which the lower end of the esophagus is involved, the operation may be performed, as Doctor Lahey suggests, with fewer hazards if confined to the abdomen.

I hope Doctor Lahey will not mind if I differ with him on one point, that is the necessity of dissecting out all ulcers of the duodenum. I believe this is unnecessary in the great majority of patients and that the ulcer will heal if isolated from the flow of gastric contents and put at rest. I do not believe there is any connection between the presence of an ulcer in the inverted duodenal stump and the occurrence of a postoperative peptic ulcer of the jejunum.

DR. SAMUEL F. MARSHALL, Boston, Mass. (closing): One must emphasize, as Doctor Rienhoff has done in his presentation, that, after all, the patients who finally come to the surgeon for treatment represent the failures under medical management, or the patients with serious complicated ulcers who cannot be relieved of their symptoms without some form of surgical procedure. I am sure that the ulcer recurrence rate can be greatly reduced by an adequate resection of the stomach. In our own experience, approximately only 7 per cent of patients with duodenal ulcers required operation. During a period of seven years we have done resection in 367 consecutive cases and of this group, 62 were done for jejunal or recurrent ulcer, with a mortality of 2.2 per cent for the entire group. Our rate of recurrence of ulcer in this group is probably less than 3 per cent.

With regard to gastrojejunocolic fistula, the question has been raised relative to removal of so much colon, whether it is necessary to carry out such a radical procedure. We know that in some cases with small fistulae, with only moderate amount of inflammatory reaction about the fistulous tract, one can excise the fistula and restore normal continuity of bowel, but it is with this type of operation that the mortality has been so high. If resection of the colon is necessary it is much safer to remove the right colon and transverse colon to a point beyond the fistula than it is to do a segmental resection and to attempt a primary colon anastomosis. Our own experience has demonstrated that the mortality can be reduced by the procedure presented here today, that the involved colon and jejunum can be more safely removed in this manner, and that this removal makes resection of the stomach much easier.

FULL-THICKNESS SKIN GRAFTS FROM THE NECK FOR FUNCTION AND COLOR IN EYELID AND FACE REPAIRS

LT. COL. JAMES BARRETT BROWN, M.C.

ST. LOUIS, MO.

AND

MAJOR BRADFORD CANNON, M.C.

BOSTON, MASS.

FULL-THICKNESS GRAFTS from the neck and the clavicular region have been found to give superior results in the repair of facial defects. The amount of skin available is limited, but there is enough for eyelids, the nose, and about the mouth.

Two main advantages are improved function and color. The graft was first used on the lid, and many full replacements of the lid skin hardly can be distinguished at only two or three feet distance. The color is nearly always close to that of the normal face and is due to the good color of the neck skin, plus the good function that is possible, and to the actual extra thickness that these grafts have over the usual thick-split or full-thickness graft. None of these grafts so far have had to have pigment injection for color matching, whereas, dead whiteness or darkness of other grafts often leaves much to be desired. There is natural redness in these grafts not found in other skin and this redness is the reason for the match with the surrounding skin. (On a burned face that has healed to a dead white, these grafts give a noticeable contrast, although they are the closest to normal).

The second advantage is softness and, therefore, function. This function, of course, is of underlying muscles, but these grafts heal in so soft and have such thickness that the best kinesis of grafted areas can develop. This property again is best expressed in eyelid repairs, where hard, board-like scars of gasoline and phosphorus burns have to be literally dug out of the lids and across from one eye to the other over the nose. When these areas are covered with the neck grafts, there is often a dramatic relief of scar fixation and return of softness and function.

The good function is due to the thickness and softness, and possibly because of the character of the skin which, in its natural habitat, overlies a platysmal muscle. This point has not been proven so far, but the result of an eyelid's being soft, of normal color, giving normal function, healed in, with practically no edge scar, in two to three weeks after grafting, brings up the platysmal idea.

Late function is excellent as there is minimal contraction of the graft bed when these grafts are used.

* Read before the Fifty-sixth Annual Session of the Southern Surgical Association, December 5–7, 1944, Hot Springs, Va.

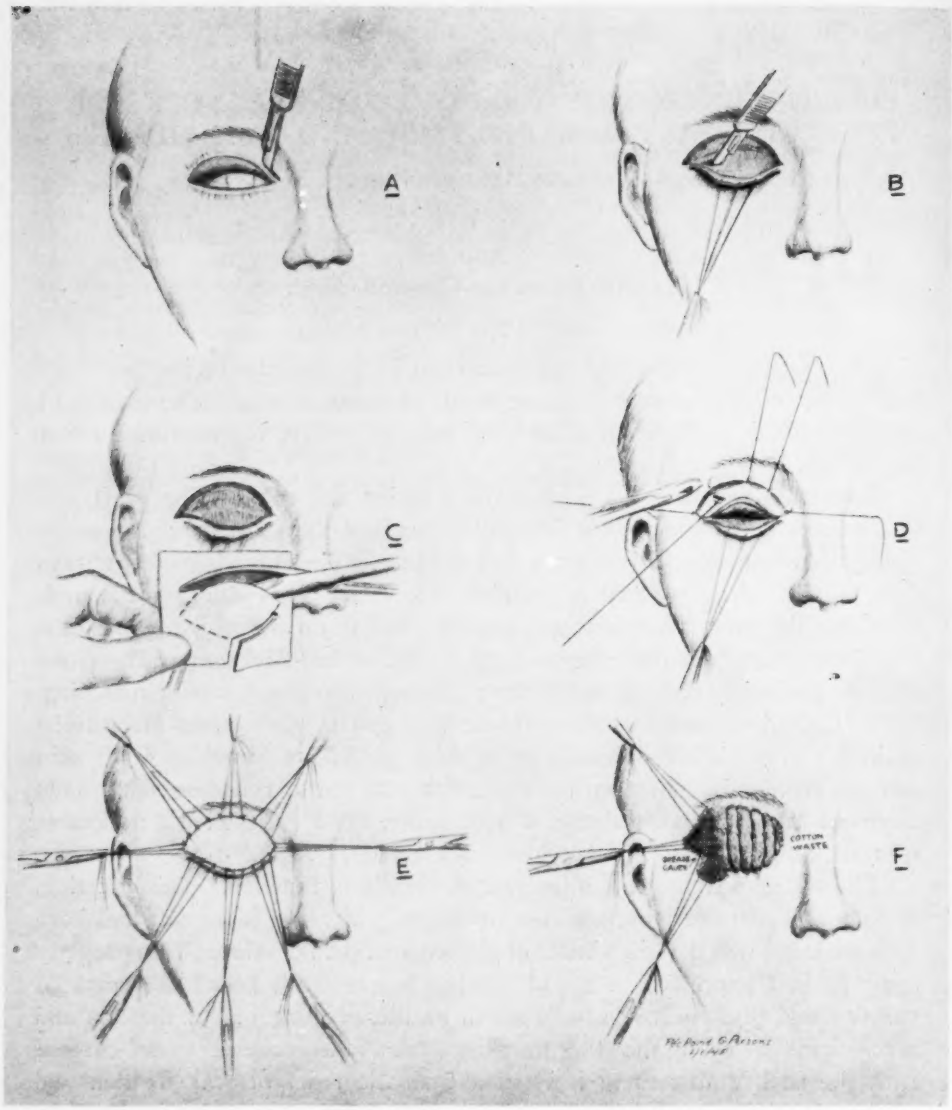

FIG. 4.—Contracted area opened; surface and deep scar removed as necessary, to allow a little more than normal expanse. Where pressure alone can not be relied on—as on the lids—the fixation is obtained and the proper opening of the area and the proper stretch of the graft obtained by the long sutures being tied over cotton mechanics waste carefully packed into place, after covering the area with fine mesh grease-gauze.

This graft is usually superior in color and function to those from other preferred areas, such as the mastoid and inguinal regions.

The main areas for use are on the lids, in the canthal regions, about the

FIG. 1a-1b.—Restoration of lid skin and function, and fairly normal color-match with graft from neck. One operation.

FIG. 2a-2b.—Restoration of skin of both lids, and function and color with neck graft. Older graft around inner which was taken from a distant area shows variation in color. One operation for each lid.

FIG. 3.—Repair of contracture of lower lip with graft from neck; color-match and function about normal. One operation. Color can be compared with grafts on upper lip, which were not from neck. Color injection of the upper lip has been done later by Miss Gertrude Hance, in consultation with Dr. L. T. Byars.

FIG. 1A

FIG. 1B

FIG. 2A

FIG. 2B

ala, over the nose and about the lips and angles of the mouth. As a rule, flap repairs are considered for gunshot wounds, whereas, grafts usually suffice for burns. However, about the lids, if a bed at all suitable can be obtained by dissection of the scars, these full-thickness grafts are used in preference to flaps and, it is thought, with better results.

Donor sites can be closed, left open to granulate, or grafted. They may make troublesome scars for a while, but no permanent severe trouble has been

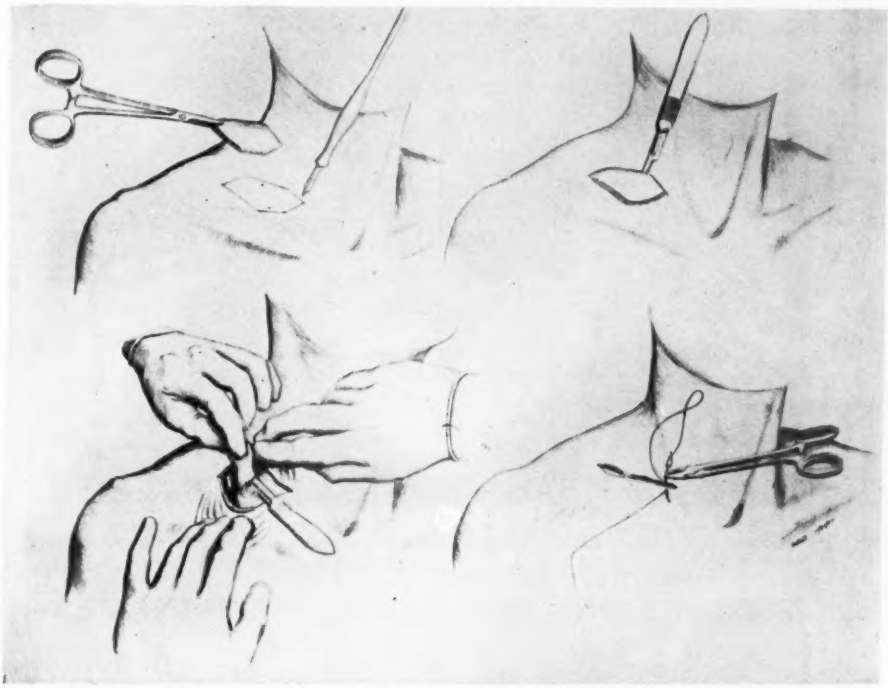

FIG. 5.—Celluloid or pliofilm pattern marked on neck; tension produced by assistants for ease of removal; fingers hold graft to avoid crushing. Wound closed.

seen. Large scars would be objectionable in women, but this does not preclude the use of small grafts.

TECHNIC OF PROCEDURE

The scarred or deformed area is dissected free and the edges are moved back to their normal position carefully, so that they are not undermined or too irregular and so that an accurate fit (or set in) of the graft can be done. With this excellent graft available, careful dissection can be done and repositioning of parts fully carried out, with the thought of accurately filling the defect and counting on only the slightest contracture of the graft bed. The pattern of the defect, in pliofilm or celluloid (roentgenogram film), is marked out usually just above the inner third of the clavicle either with methylene blue or directly with the knife. The graft is removed in the usual manner, with good firm stretching by assistants to produce a "drumhead" to work on.

After an edge is freed, fingers are used to hold the graft instead of forceps or hooks and the dissection is completed carefully at the proper full-thickness depth so that no trimming of the under surface of the graft has to be done later. These grafts appear so thick that their growth might seem questionable, but growth of them has been as good as of split grafts, and there has been none of the spotty necrosis sometimes seen in full-thickness grafts.

Donor sites are usually closed, or are partly closed and partly left open, or covered with a split graft.

FIG. 6.—Resurfacing of right upper lip with graft from neck after correction of deformity and reconstruction of nostril. Color-match and function about normal. Two operations.

FIG. 7.—Complete fixation of tongue in scar, released by dissection, the resulting raw surface covered with graft from neck in endeavor to get good soft tissue to allow function. Good movement nas been permitted from one operation. Lined flap has been delayed on neck for final repair.

Application of Grafts.—These grafts are set in accurately with interruptured sutures of light silk, every two to four millimeters around the borders. The ends of the sutures are left three to four inches long for subsequent fixation of a waste form, and each two sutures are clamped with a mosquito clamp. No holes are cut in the graft. The graft is covered with fine mesh grease-gauze and a wad or form of white cotton, mechanics waste is packed carefully over this, to assure firm coverage of the entire graft.

Appropriate opposite sutures in pairs are selected for the first anchorage

and as the assistant firmly compresses the waste with his fingers or instrument, these opposing sutures are firmly tied over the waste. The remaining sutures are tied over the waste in pairs. The eye is protected with a suture closing the lids if necessary, and usually a larger over-all waste pressure dressing is applied, with a gauze roll going around the head, to obtain counter pressure posteriorly. This fixes the whole area and is usually more comfortable than just the small waste form without further fixation.

Dressings are done on the 3rd to 6th day, and subsequent ones are repeated as necessary, usually having them off about the 10th day.

Suturing these grafts in place is essential if a full edge-to-edge take is desired. Contracted areas, such as on the lid, are dissected and then are pulled outward with the sutures over the waste to establish the complete area of opening and the fixation at the same time. A gluing method of fixation is not applicable by itself, though it also may be used if its added fixation is thought to be of benefit.

Because these grafts have been widely used, some chances of infection have naturally been taken about the mouth and nose, but there have been no full-thickness losses. A few have desquamated some epithelium, and have been brown and then red for a fairly long period, but this has finally cleared up, with some residual redness and a slight glaziness.

The graft has been used successfully to free a totally restricted tongue, and its use on fingers and on the penis is contemplated.

This may be recognized as a standard full-thickness graft procedure, but is recorded because of the evident worth in function and in color. The slight extra work and extra care of the donor site over the usual split graft or full-thickness graft is thought to be indicated in many repairs.

This work has been done in association with Captain Carl Lischer, Captain Parke Scarborough, Lt. Bowdoin Davis, Lt. Andrew Moore and Lt. Col. James N. Greear, Jr., and his associates on the Eye Service.

TATTOOING OF FREE SKIN GRAFTS AND PEDICLE FLAPS*

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SKIN COLOR is partially due to the presence of certain pigments of the skin, as in the Negro or the dark complexioned individual. Another factor producing color variations in various areas of the body is the type of blood flow through the skin. For example, a small scratch on the face may bleed annoyingly for several minutes, whereas a similar cut elsewhere on the body may bleed but a drop or two. It is chiefly this factor of capillary flow which gives the red tone to the skin of the face, ears or neck. Of necessity, free skin grafts or pedicle flaps are often applied to the face. When free skin grafts are taken from the postauricular region or from above the clavicle and applied to the face they usually match the skin well in color. Pedicle flaps of forehead tissue also match the face well in color but necessitate the use of skin from elsewhere to cover the defect of the donor site. Skin taken from other parts of the body and applied to the face may be whiter or darker than face skin, but the chief factor in the color contrast is the absence of the red tone (Fig. 1).

Heretofore, after function and contour had been restored by surgery, the patient often had to resort to the use of cosmetics for a reasonably good appearance. This has been for the most part unsatisfactory, especially with men. During the past eight years, the cautious but increased use of pigment injected permanently into the derma has proven a safe and satisfactory adjunct to surgery to produce a better cosmetic result.[1]

Tattooing is the practice of depositing permanent pigments within the skin and has been employed for thousands of years, either for decorative or religious purposes or to produce marks of identification. It probably has been used in an attempt to hide blemishes, and we have seen a number of patients who have crudely tattooed themselves in an effort to eliminate or camouflage bald areas in the brows or scalp. There is very little in medical literature to indicate this use of the procedure. The tattooing of white corneal scars overlying the dark pupil of the eye has been done with considerable improvement in the appearance of the eye. It is obvious that the pigments employed must be nonpoisonous, nonirritating to tissues, extremely insoluble and inert to body metabolism. The pigments which we have employed have been provided by those firms supplying tattooing equipment to professional practitioners. Chemically, there is probably considerable variation in their content as there is in their shade. Black is carbon; white is barium sulphate. For the most part, the yellows, browns and reds are earthy metallic oxides, the color being

* Read before the Fifty-sixth Annual Session of the Southern Surgical Association, December 5–7, 1944, Hot Springs, Va.

controlled by the amounts of hematite and limonite present. Clay or chalk is sometimes contained. Cinnabar, mercuric sulphide, is one of the red pigments sometimes used. Umber, a brown ocher, contains some manganese.

*Technic**.—The procedure is carried out in as near an aseptic manner as possible. The area is prepared with soap and water and alcohol, the pigments are autoclaved and the instruments sterilized. The skin must be free from infection. The procedure is somewhat painful except when used on a skin graft or flap which has not yet regained its sensation. In hospitalized patients, analgesia may be obtained with the barbiturates. Otherwise a

A B C

FIG. 1.—A: Defect resulting from destruction of a malignant lesion involving the ala of the nose and adjacent cheek.
B: Repair partially completed with two flaps, one to piece out the cheek and the other to form the ala. The cheek flap has been pigmented by color injection and the contrast is shown between this and the nose flap which still has its original color. Transplanted tissue was from the arm.
C: Final result and after pigmentation of both cheek and nose flap to match adjacent tissues.

novocaine block of the area is more satisfactory than infiltration anesthesia. The dry pigments are mixed thoroughly on a clear glass slab and moistened with normal saline until about the consistency of thick cream. For matching a graft to the face skin, one starts with small amounts of red, yellow and white. The correct mixture will be a shade darker than the skin. Spreading a thin coat of the trial mixture over the contrasting area helps in obtaining a match. Often after the red, yellow and white are blended, a small drop of black is added. The mixture must be blended in different proportions in almost every case.

Professional tattooers use an electrical vibrator with multiple needles to carry the pigment into the skin. This is a rapid method and it is essential in doing large areas. Unless one has developed self-assurance, it is perhaps better to proceed more slowly, using multiple needle points soldered to a handle to prick the pigment into the derma by hand. The pigment is picked up on the points and the needles inserted obliquely into the depths of the

* Pigment injection was undertaken on the illustrated cases by Miss Gertrude Hance, 400 Metropolitan Building, St. Louis, Mo.

skin. The needle pricks must be very close together, although with time there is dispersion of the pigment, which gives a more uniform appearance and relieves the splotchy early appearance. The excess pigment is constantly wiped from the surface so that the evenness of the injection may be observed. There is a period of fairly severe inflammation, lasting a week or ten days, following which there is desquamation of the surface. The color gradually diffuses and pales somewhat. Patchy areas may appear. A second treatment is often needed, at which time color discrepancies can be corrected and patchy areas blended. It is better to err on the side of under- rather than over-pigmentation.

FIG. 2.—Upper picture shows thin, atrophic scar resulting from radiation of an angioma. The middle picture shows the lesion replaced with a pedicle flap from the arm. The color contrast between the transplanted tissue and the forehead is definite. The lower picture shows color matching of the transplant to adjacent tissue by pigment injection.

Selection of Cases.—In general, the uses of this procedure are (1) to match contrasting areas, such as skin grafts, to the surrounding facial skin (Fig. 3); (2) to simulate missing vermilion of the lip; (3) to blend-in rather patchy scarred areas to give a more uniform appearance; and (4) to camouflage bald areas within the eyebrows.

Hard scarring interferes with the process of insertion and spread of the pigment; soft scars are amenable to injection.

We have had little experience with its use in the Negro. In one such case where irregular areas of depigmented scar were present on the nose and forehead as the result of a burn, Lt. Col. James Barrett Brown employed the procedure with some success at Valley Forge General Hospital.

Skin Grafts.—New skin grafts are thick and leathery. As they get older the quality of the skin more closely approaches normal. For this reason it is better to wait until a graft has achieved its greatest degree of relaxation and flexibility. Such a skin graft may be dead-white, yellowish, or brown. The white graft is of course most ideal, but by taking into consideration the color of the graft when blending pigments it is possible to improve greatly the color match of even the less ideal areas (Fig. 3).

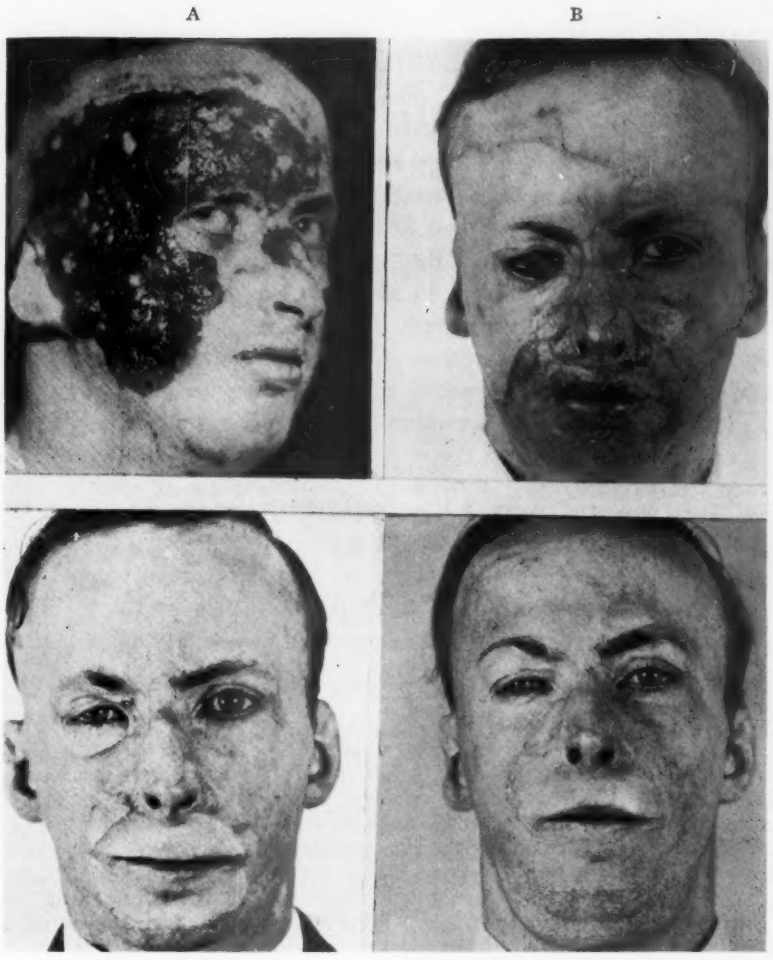

FIG. 3.—A: Original condition six weeks after burn.
B: Healing obtained at first operation by applying split graft to the granulating wound. Considerable keloiding has developed in the areas which healed spontaneously and there is a marked ectropion of the lower eyelid on the right.
C: Repair as far as contour and function has been completed. Lower eyelid is in good position. The heavy scarring about the face has been removed and replaced with free full-thickness skin grafts. These grafts are very white and quite noticeable.
D: Skin grafts have been matched to adjacent tissue by pigment injection. Note the vermilion of the upper lip which has been emphasized by the same process. Partially missing right eyebrow has been camouflaged in the same manner.

Skin Flaps.—The texture of the pedicle flap is often better than that of the free skin graft and does not require as long a period to become soft and pliable. Usually, the color of the pedicle flap remains much as it was on the donor site. There does not seem to be the tendency to discoloration from condensation of pigment as occurs with the thinner free grafts. The flap is more commonly used in the reconstruction of features, such as the nose, lip, or full-thickness of the cheek (Figs. 1 and 2). Oftentimes the total area of the face covered by flap is not nearly as great as with the free skin graft which has been used to correct a widespread burn.

Vermilion of the Lip.—Regardless of the perfection of contour of the reconstructed lip, the appearance is artificial without a vermilion. The use of lip-stick is not satisfactory because lip-stick does not produce the normal, unretouched vermilion, and with men its use is obviously undesirable. When lip-stick is smeared, the underlying absence of the vermilion is doubly noticeable. The vermilion is occasionally destroyed fully or in part by chemical or fire burns, and the simulation of the normal vermilion in either situation aids greatly in producing a normal-looking result (Fig. 3).

Bald Areas.—Bald areas in the eyebrow may be well camouflaged (Fig. 3). An attempt to simulate an entire missing eyebrow gives the same effect as the use of an eyebrow pencil. Occasionally small bald areas within the scalp may be made less noticeable. One should be cautious in attempting to stipple a bald area on the bearded portion of the face. This is likely to cause a dirty appearance, which would be unsatisfactory.

SUMMARY

Intradermal pigment injection has been undertaken in over 60 cases for the purpose of matching skin grafts and flaps to adjacent facial tissue. There have been no complications. In each case improvement was gained. The degree of improvement varies with the type of case and skill of injection. This procedure has been regarded by the patients as being well worth while.

REFERENCE

[1] Hance, Brown, Byars, McDowell: Surg., Gynec. and Obstet., **79**, 624, 1944.

DISCUSSION.—DR. JOHN STAIGE DAVIS, Baltimore, Md.: I was very much interested in both these papers. What Colonel Brown has shown us is the highest type of military plastic surgery. It has been my privilege to be at Valley Forge Hospital on more than one occasion and I have seen some of the extraordinary plastic surgery being done there. It is an eye-opener; nobody who has not seen what is going on can realize the magnificent work being done in the hospital. I was greatly impressed with the morale of the patients in the plastic wards; it was unbelievable. These men, with terrific deformities of all types, are cheerful and hopeful; it is marvelous to see how they are handled, and I take my hat off to Colonel Brown, and his associates, for the way the morale of these men is kept up.

The procedure described in Doctor Byars' paper is unquestionably a very useful one. I have, so far, not had anyone who was capable of doing these injections properly, but I hope to have someone trained to take care of the glaring white defects and the defects in eyebrows and lips. His method, I think, will bring about a wider use as the technic becomes known.

TANTALUM CRANIOPLASTY FOR WAR WOUNDS OF THE SKULL*

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AND
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THE REPAIR of skull defects resulting from war wounds of the head has become a major task of the rehabilitation neurosurgeon. During the past year, head injuries comprised 5.9 per cent of our total casualties and approximately one-fifth of these were open head wounds. The care of such injuries is divided by the very nature of the lesion among several echelons of medical support. In the first place, it has been estimated that 50–60 per cent of the men never seen alive again after entering a decisive engagement have fatal wounds of the head, although they may exhibit other potentially fatal injuries as well. The mortality among those that survive varies between 15 per cent[1] to 14 per cent[2] to 22 per cent.[3] The preservation of life and the prevention of infection by débridement and primary closure are the functions of the evacuation hospital or the special surgical unit; the treatment of infection and the guidance of the late stages of convalescence are the responsibilities of the base or numbered overseas general hospitals.

As we have pointed out recently,[4] when the patient with a healed head injury returns to the Zone of the Interior, he presents one of two problems and frequently both. The first comprises an evaluation of the existing neurologic defect, carried out by neurologic and psychiatric surveys, supplemented by electro-encephalography and pneumo-encephalography. Such an evaluation is a pertinent factor in determining disposition to duty or some other status. The second problem is that of repairing skull defects in otherwise fit individuals for return to duty or in patients whose skull defect represents merely a part of a disabling cerebral injury. The repair of such skull defects in Army personnel, caused by gunshot wounds and by operative relief of traumatic intracranial hematomas and as a sequel of cerebral tumor or infection has been carried out in 79 patients at the Walter Reed General Hospital, for the most part during the past 11 months. Half of these patients have thus far been returned to some type of duty. An incomplete estimate of the magnitude of this problem may be derived from the statement that the Walter Reed General Hospital is but one of 19 neurosurgical centers in the Zone of the Interior.

Before the repair of a skull defect is accomplished in any one patient, an evaluation, not only of the existing neurologic defect, but also of the potential epileptogenic activity of the concomitant cerebral scar is attempted. With the time interval between initial injury and our observation of these cases steadily lengthening, it has become apparent that the posttraumatic

* Read before the Fifty-sixth Annual Session of the Southern Surgical Association, December 5–7, 1944, Hot Springs, Va.

† This report was prepared while Lt. Col. Spurling was on overseas duty.

convulsive state will be an important disabling sequel of penetrating injuries of the brain, as it has been in the past. Studies to be published shortly[5] show that in a series of 76 penetrating injuries of the brain observed over a time period of approximately one year or less, 15 have developed convulsions within four months of the injury and that a further 15, a total of 40

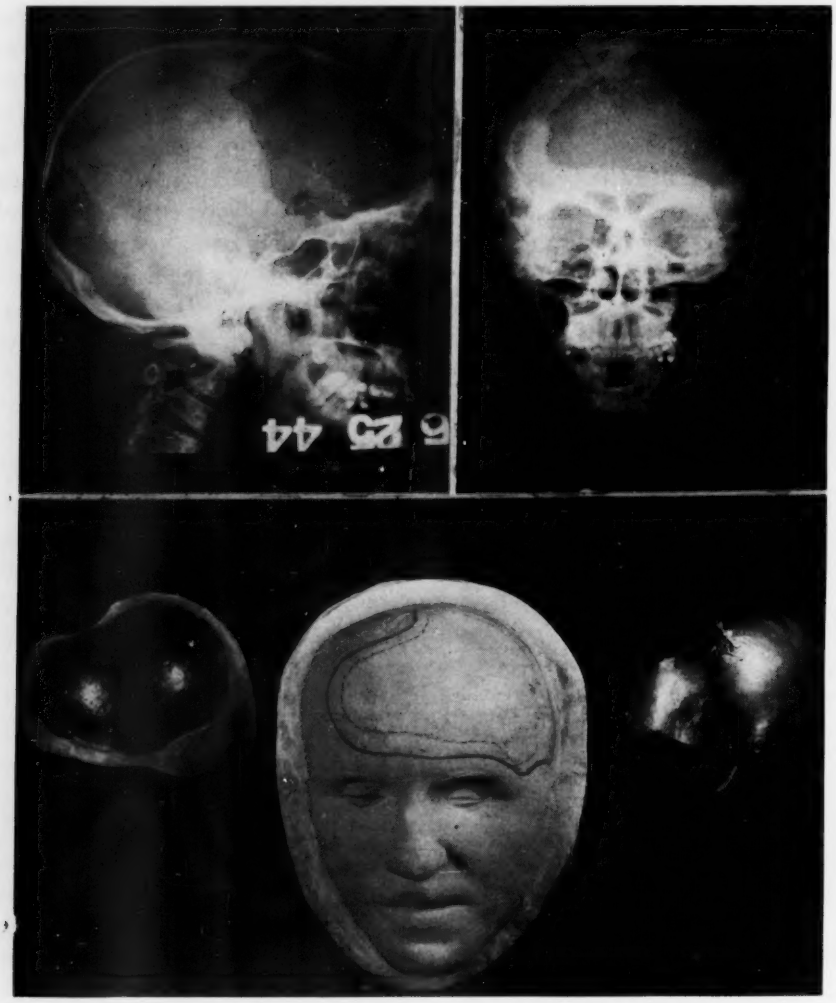


FIG. 1.—Extensive bifrontal defect following a mine explosion. The dental stone impression of the defect, the wax restoration and the completed tantalum plate are illustrated.

per cent, now exhibit electrical cortical activity highly suggestive of an epileptogenic focus. It may be noted in passing that these patients have shown a highly favorable if early response to the conservative regimens of treatment developed during recent years.

INDICATIONS FOR CRANIOPLASTY

The indications for the repair of a skull defect have been established by

the observations made upon many patients by numerous surgeons and have been stated succinctly in the classical paper upon this subject by Grant and Norcross.[6] Such indications include:

(1) Headache and other symptoms of the syndrome of the trephined, including vertigo, local tenderness, fear of injury and a subjective feeling of insecurity, easy fatigability, mental depression and intolerance to vibration.

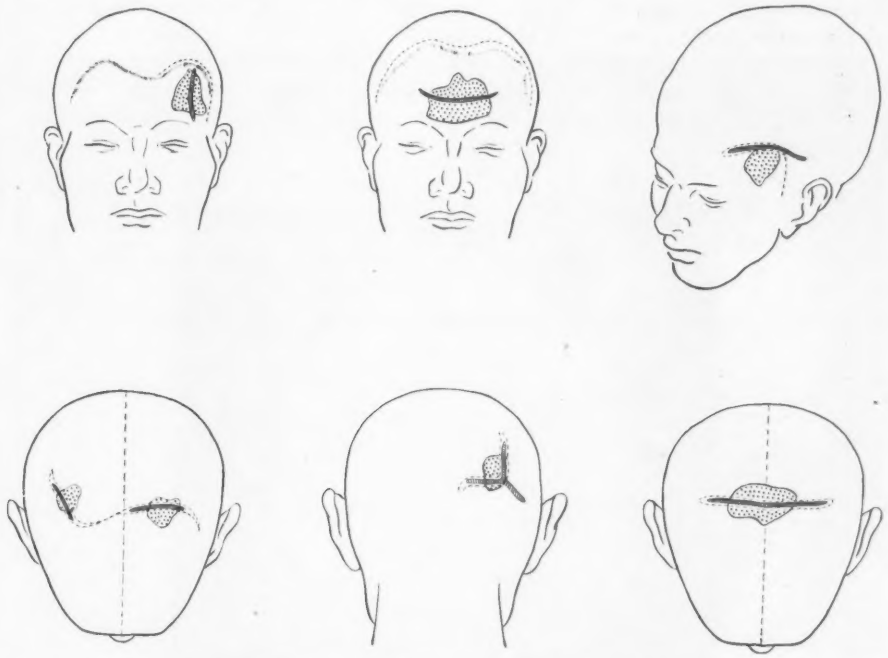


FIG. 2.—Various scalp scars following débridement of the initial injury. The proposed scalp incisions for cranioplasty are indicated with broken lines.

(2) Undue pulsation of the underlying brain.
(3) Exposure to trauma of the underlying brain.
(4) Cases with deforming and repulsive defects, and
(5) The assumed relief of an associated convulsive state.

To these more or less cogent reasons, may be added certain military regulations governing the handling and disposition of such patients when they are treated under service conditions. Under AR 40-105, par. 23 e, an applicant for a commission in the Army of the United States may be rejected for "depressed fracture or loss of bony substance of the skull." Under MR 1-9, an individual fails to meet minimum requirements for induction into the Army if under par. 40 a, he possesses "deformities of the skull in the nature of depressions, exostoses, *etc.*, of a degree which would prevent the individual from wearing military headgear." The profile supplement to MR 1-9 places patients with skull defects of this character in a permanent restricted duty status, and in order to gain a more advanced duty status, cranioplasty is indicated.

Thus, in the practice of military neurosurgery, it is imperative to repair all skull defects over three centimeters in diameter if a return to duty status is desired. That this is advisable in the rugged existence of Army service is validated in part at least by three isolated instances that have come under our personal observation.

Case 1.—P. S. S., Reg. No. 210122, age 23, was operated upon in the Walter Reed General Hospital on July 31, 1942, for the relief of an acute subdural hematoma in the left temporal region, the result of a baseball injury sustained on July 17. A four-centimeter skull defect in the left temporal region and a two-centimeter defect in the left temporal region were caused by the operative procedure. His convalescence was without incident and he was returned to duty. On March 6, 1944, he took part in a grudge fight with regulation boxing gloves. He received a series of blows on the

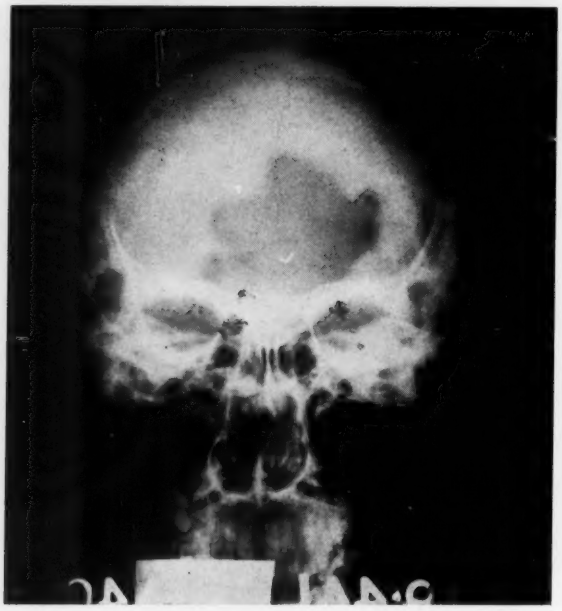


FIG. 3.—Case 1: Bifrontal skull defect caused by fragment of aerial torpedo.

head and 48 hours later, bilateral subdural hematomas were drained at this hospital through the preëxisting skull defects.

Case 2.—M. F. S., Reg. No. 195005, Walter Reed General Hospital, age 27, was struck in the left frontal region by a bayonet on January 9, 1942. The resulting compound comminuted skull fracture and cerebral laceration were débrided after resection of a 3–4 centimeter bony defect. After return to duty, he developed severe head pain, localized at the point of injury, from the pressure of a steel helmet. His symptoms were relieved by tantalum cranioplasty on July 17, 1943, with subsequent return to active duty.

Case 3.—Ashford General Hospital. W. W., age 24, a fighter pilot, assayed a return to duty with a small 3.5 centimeter defect in the right occipital region. Rapid acceleration of his aircraft caused localized pain, and more significantly, blurring of vision. Both disturbances were relieved by cranioplasty.

It seems apparent to us, after two years of experience in these problems, that the important and realistic indication for the repair of a skull defect in military personnel is the simple existence of such a defect over three centimeters in diameter. In personnel who will not return to duty because of a coexisting cerebral injury, the form of cranioplasty to be described is carried out, in the hope of alleviating in every possible way the effect of the initial injury.

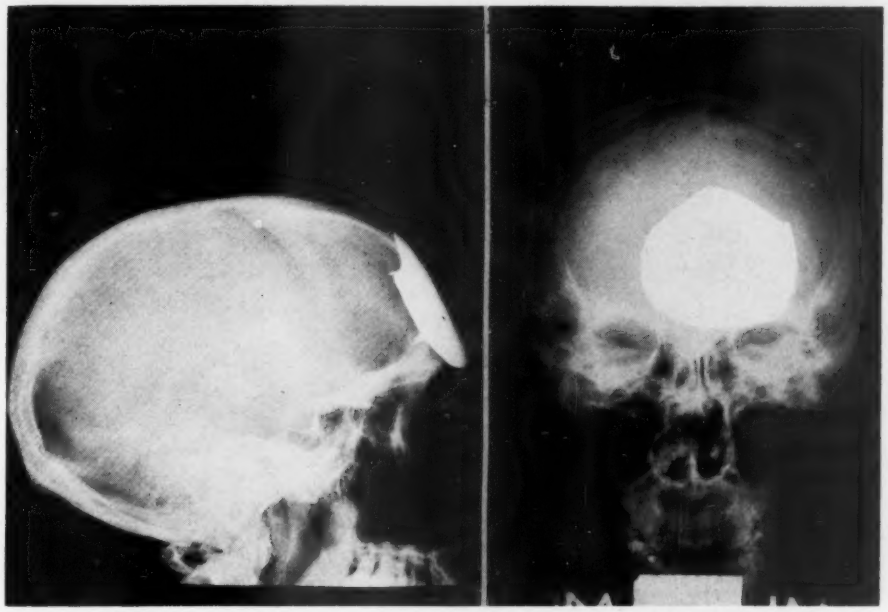


FIG. 4.—Case 1: Roentgenograms of tantalum plate inlayed in bifrontal defect and early postoperative cosmetic result. The broad scar of the original injury may be removed at a later date.

Materials Used for Cranioplasty.—Cranioplasty, being an operation essentially in the domain of plastic surgery, has been favored by the application of much surgical ingenuity in the use of many substitute materials. Its history has been described by Grant and Norcross and reviewed recently by Reeves.[7] Both papers have noted the use of such substances as animal bone, celluloid, aluminum, gold, the fabled silver plate, platinum, autogenic and heterogenic bone, cartilage, sliding grafts of cranial bone, decalcified bone, buttons of bone and chips of bone. A modern innovation in the use of bone chips and whole blood has been recorded by Converse, Clarke and Guidi.[8] There appears to be little doubt that until the appearance of certain alloplastic substances, autogenous bone derived from the adjacent cranium, the ilium, the ribs or other osseous structures, was the material of choice for cranioplasty. However, the plastic repair of extensive defects was not always feasible with the use of autogenous bone and the method suffered from the necessity of a second and frequently major operative procedure designed to secure the graft.

The use of alloplastic substances for the repair of skull defects received impetus by the reports of Geib,[9] Beck,[10] and Peyton and Hall,[11] describing the clinical advantages of the tissue-inert alloy, vitallium. Its wide application in cranioplasty has been deferred by the fact that vitallium plates must be cast and are not amenable to any degree of secondary adjustment. The use of vitallium implies a two-stage operative procedure and this and other defects in the technic have been answered only partially by Beck's employment of vitallium strips cast in various and perhaps standard sizes. The clinical use of zirconium, whose experimental reactions in tissue have been described by Campbell, *et al.*,[12] has been deferred by the onset of the war.

The use of certain synthetic resins has shown distinct, but as yet unproven, promise in cranioplasty. Certain resins appear quite inert in tissue,[13] and among these is methamethylacrylate (plexiglass). Gurdjian

FIG. 5.—Case 2: Left frontal, supra-orbital and orbital plate skull defect from shell fragment injury.

has reported a single, but significant, instance of its use in the repair of a skull defect following removal of a meningioma.[14] Sheldon has used it successfully in his series of studies upon head injuries, marked by observation of the living brain through an acrylic skull plate.[15] Cameron and Elkins[16] have completed some 30 cranioplasties with methamethylacrylate and their results, to be published shortly, may reveal a new chapter in cranioplasty.

The Use of Tantalum in Cranioplasty.—In September, 1942, one of us (R. G. S.) performed the first cranioplasty with tantalum in the Walter Reed General Hospital. This clinical trial followed the experimental observations of Burch and Carney,[17] Burke,[18] and Pudenz,[19] and the early clinical trial by Fulcher.[20]

These studies demonstrated the existence in tantalum of the two essential features of any material used for skull defect repair. In the first place tantalum is relatively inert in tissues and may be considered absolutely inert for all practical purposes. A thin, translucent connective tissue capsule does appear

about this element, well known to military surgeons who have explored peripheral nerve lesions protected by another form of tantalum—tantalum foil. This apparently nonprogressive connective tissue reaction was described by Pudenz,[19] and has been noted also by Pudenz and Odom,[21] and by

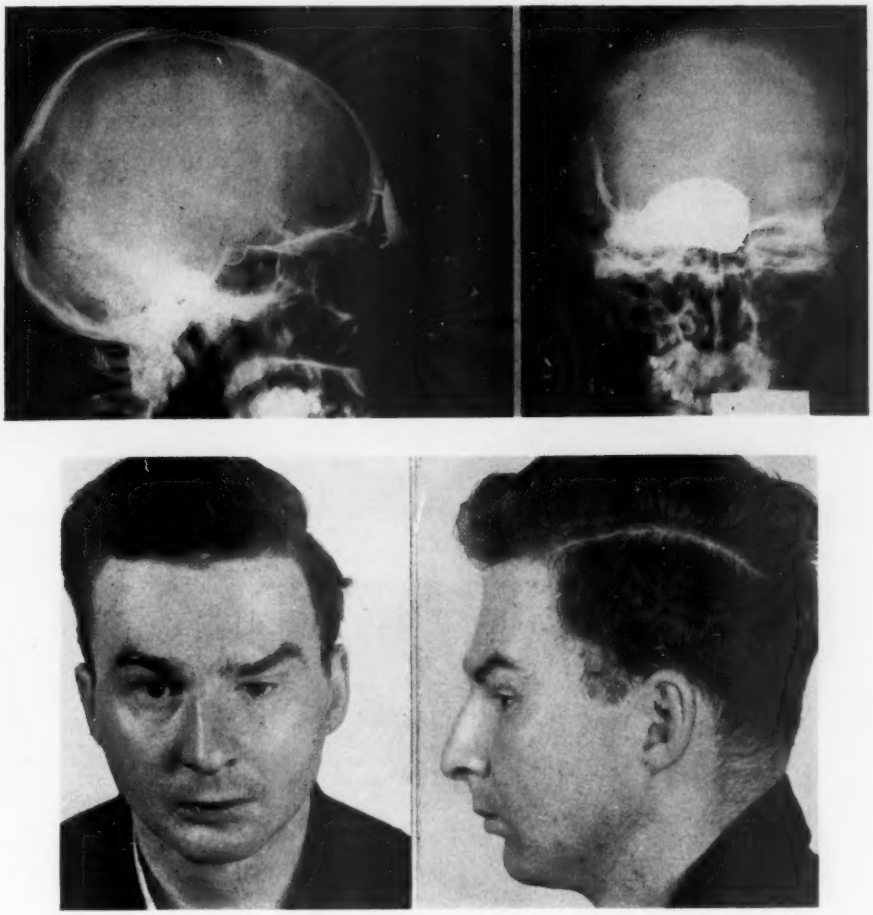


FIG. 6.—Case 2: Roentgenograms of tantalum cranioplasty and cosmetic restoration after insertion of orbital prosthesis.

Delarue, *et al.*[22] In our series of cases, there has been no clinical evidence of tissue reaction to the insertion of tantalum plates, some of them massive in size. No reactions to heat, cold or electrical fields have been a source of complaint to our patients. Pudenz has described proliferation of bone beneath the tantalum plates in his experimental animals. We have had no opportunity to study such a plate after its insertion and the reaction of tantalum to the roentgen ray precludes roentgenographic study of new bone formation.

The second, and desirable, feature of tantalum is its malleability without loss of strength. Flat sheets .015 or .020 inches in thickness and six inches square are available in the neurosurgical centers at this time and larger sheets may be obtained if necessary. The ductility of this bluish-white

element, the 72nd in the periodic table, allows it to be drawn into wire, rolled into sheets of various thicknesses, or formed into structures such as bone plates, ribbon or screws. Its strength may be considered comparable to steel. Whether formed by preoperative molding in a dye and counterdye

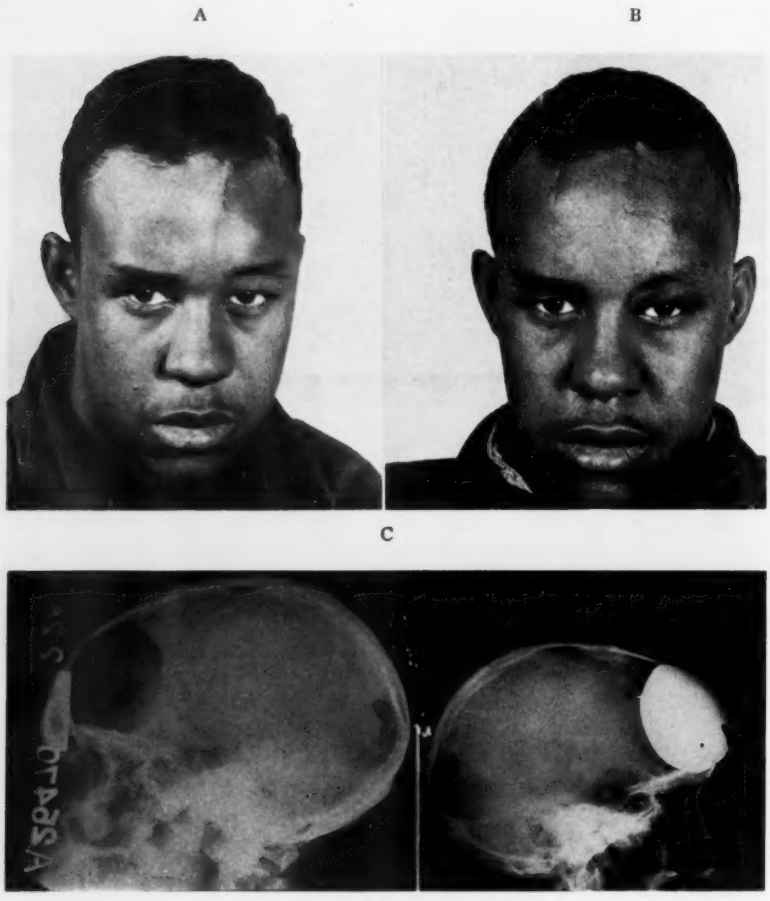


FIG. 7.—Case 3 (A) Skull defect following resection of osteomyelitic bone.
(B) Same patient following tantalum cranioplasty.
FIG. 7.—Case 3 (C) Roentgenograms of skull defect and tantalum repair.

or by rough molding at the operating table with a hammer and rounded form, this inherent malleability allows adjustment by cutting or contour changing at the time of operation and, thus, dispenses with multiple operative procedures.

The Preparation of a Tantalum Plate—Indirect or Primary Method.—One of the several technics evolved for the preparation and insertion of tantalum plates has been described by Hemberger.[23] With the exception of early exploratory efforts in this type of cranioplasty, we have adhered to this technic in the remaining cases of our series. Briefly stated, the method is as follows:

After removal of the long hair, the margins of the skull defect are palpated through the scalp and delineated with an indelible pencil. Dental compound is softened in warm water and molded into the defect and for a considerable distance upon the surrounding scalp. A model is formed by pouring dental stone or plaster into the mass of hardened dental compound and upon this cast, the mark of the indelible pencil will persist. The depressed area within the cast, representing the depth and extent of the bone defect, is filled with wax and contoured to fit the surrounding scalp outline. In complicated frontal defects, this temporary wax prosthesis may be placed in the actual skull defect, in a supra-orbital defect for instance, and compared roughly with the opposite side. In the infrequent deforming bilateral defects, the wax restoration may be studied for verisimilitude by the patient or by relatives. In the uncomplicated defects of the vault of the skull, the convexity of the wax-fill should be overemphasized to compensate for the customary thinning and scarring of the overlying scalp and for the subsequent slight inlay of the plate. A mold is next made with any of the molding sands, including the wax restoration and an ample mass of the adjacent skull contour. A dye is poured with zinc or in larger defects with hydromite. The surface of the dye, after cooling, is painted with a solution of alcohol and talc. A soft clay, such as moldine, is adapted about the circumference of the zinc dye to act as a mold for a counterdye of poured lead. The same procedure is followed when hydromite is used. The required size of .015 inch tantalum plate is roughly fashioned with at least a one centimeter greater diameter than assumed necessary to compensate for the varying convexity of the plate and for possible enlargement of the bony defect at the time of operation. The plate is swedged between dye and counterdye with a hand or hydraulic press. In the swedging of large and complicated plates, the flow of the element under pressure may be associated with kinking or furrowing. Local adjustment of such changes by hammering will allow completion of the press in successive stages. After the initial press, the edges of the plate are smoothed with carborundum and it is polished with an abrasive disk. A single hole is bored in the proposed dependent portion of the plate or in its central portion for drainage purposes and the plate is reswedged. We have had no experience with plates prepared with multiple perforations but have not used this minor variation in preparation of the plate for fear of causing undue fixation of the scalp to the underlying plate. The proposed use of stainless steel wire mesh[24] for the repair of skull defects may be mentioned at this time, since it makes use of a similar principle of multiple perforations. Before use, the plate is cleansed in laboratory cleansing fluid, washed in running water and sterilized in an autoclave. The materials and apparatus required for the formation of such plates are available in any dental laboratory and the skill and experience of Army dental officers in these matters have been of considerable aid in the treatment of the patients reported in this paper.

Operative Fixation of the Plate.—The majority of our operative pro-

cedures have been undertaken under local anesthesia, and the required lining and chiseling of bone has been well tolerated with the aid of heavy sedation consisting of nembutal grains 1½, 90 minutes before operation and morphine grains ¼ and atropine grains 1/150, 30 minutes later. In unilateral and bilateral frontal defects, the use of a coronal scalp flap and manipulation about the frontal sinus and orbit have demanded the use of a general anesthetic, in these cases intratracheal ether. Insertion of the plate is facilitated by placing the area of skull defect on a horizontal level and full use of the cerebellar frame, and other adjuncts to such posturing, is advocated.

Among the 79 skull defects repaired, 62 were caused by direct enemy action and the definitive treatment of the acute injury was carried out by overseas neurosurgeons. In 54 of the 62 injuries, the resulting scalp scar was represented by a linear scar of varying length. Tripod or formal craniotomy scars were rarely observed; there were five of the former and three of the latter. The skull defects were uniformly oval or rounded and no defects were characteristic of formally resected areas of bone, advocated in World War I. The predominance of linear scars allowed approach to the skull defect in most cases by simple excision of the original scar, and by dissection and retraction of scalp flaps. In temporal bone defects, the usual craniotomy incision making complete or partial use of sagittally directed scars and circumscribing vertical scars is indicated since the mass of muscle and the increased vascularity following injury in this region makes direct exposure of the defect unnecessarily difficult. In frontal defects, rostral to the hair line, coronal incisions are used. Plastic revision of broad or deforming frontal scars may be done as a secondary procedure. In the rare tripod scars, exposure of one angle of the former incision may be sufficient for insertion of the plate. Cranioplastic incisions about a horizontal scar should be avoided since they will be followed by incision line necrosis. The revision of broad thin scalp scars, adherent to underlying brain tissue demand special study and may present formidable problems.[25] Typical scalp scars, defects and cranioplastic incisions are illustrated (Fig. 2).

After adequate exposure of the area of the skull defect, its edges may be readily palpated. An incision is made through the pericranium about the edge of the defect one centimeter from its margin. This pericranial tissue is resected centrally, together with any excess extradural tissue over the area of the defect. Indicated bone resection, cerebral scar resection, dural repair, or other measures, are carried out. To initiate the insertion of the tantalum plate, it is held provisionally over the defect and its margin altered if necessary with heavy cutting scissors so that it overlaps the margin of the

A.—Bifrontal skull defect from aerial torpedo fragment wound.
B.—Lateral view of bifrontal skull defect.
C.—Coronal scalp incision used for exposure of defects rostral to hair-line.
D.—Exposure of skull defect after resection of pericranium about defect.
E.—Preparation of circumferential ledge about defect prior to insertion of plate.
F.—Fixation of tantalum plate by means of tantalum wedges.
G.—Completed operative procedure.
H.—Frontal view of patient after tantalum cranioplasty.
I.—Lateral view of cranioplasty. Note restoration of frontal bone contour.

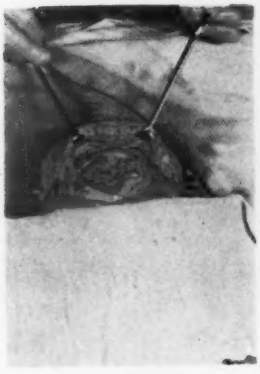
PLATE I

A

B

C

D



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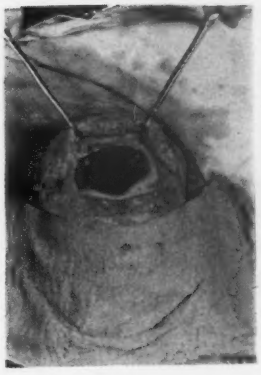

F

G

H

I

defect for an approximate distance of one-half centimeter. This border is then marked by an ordinary dental scaler and cut to a depth of two millimeters with the lineator, one of the simple instruments designed by Hemberger for this procedure. This incision into bone, at right angle to the surface of the skull forms the sharp inner border of a circumferential ledge about the border of the defect, one-half centimeter wide and two millimeters deep, formed by a Stout No. 3 dental chisel. The preformed tantalum plate is then fitted into this ledge, its upper border flush with the skull, necessary adjustments being made with cutting scissors or minor contour changes with a contour pliers. With the plate held in position by digital pressure, fixation is secured by means of tantalum triangular points, much like glazier points. Seats for the tantalum wedges in the outer border of the bony ledge are made with a triangular pointed instrument, the perforator. The tantalum wedges, made of .020-inch plate, are tapped into place in the bone, and turned inward over the edge of the plate with a wedge director. Four to six tantalum points may be used in any one case. In plates assuming a vertical position, front or occiput, wedges may be driven through a drill hole in the superior margin of the plate and the weight of the plate suspended in this manner. Following insertion of the plate and closure of the scalp, a firm, evenly distributed pressure dressing is applied, preferably with one of the new adhesive dressings, such as Nuhesive. Such a dressing decreases the number of postoperative aspirations of fluid blood which may collect in spite of meticulous hemostasis. Cranioplasty in this series of cases has been undertaken as soon as primary wound healing has occurred and has not been deferred because of a history of preëxisting cerebral infection. Prior to operation, prophylactic penicillin therapy is instituted with 30,000 units of penicillin being given every three hours for the 24 hours prior to operation. At the termination of the cranioplasty, 30,000 units are injected beneath the scalp incision (10,000 units/cc.) and 15,000 units are given every three hours intramuscularly for the following three days. Two postoperative infections developed prior to the institution of this therapy, both in postinfection cases; both were controlled without open drainage and without loss of the inlayed plate. There have been no infections under the regimen outlined above. There have been no other postoperative complications of significance.

Preparation and Insertion of Tantalum Plate—Direct or Secondary Method.—The method which has been described is applicable to the majority of the skull defects observed some time, *i.e.*, two to four months, following the initial injury. An important variation, which may have a wider application in the field of civilian neurosurgery, consists of a preliminary, direct impression of the proposed tantalum plate, and its insertion at a secondary operation. The débridement of bone in acute injuries of the skull, or the removal of a skull tumor, or the sacrifice of a bone plate at craniotomy, may suggest the desirability of a secondary repair of the resultant skull defect. In suitable cases, this repair may be facilitated by ledging the circumference of the bony defect as described previously. An impression is made of the

extent of the bony defect and the exact contour of the circumferential ledge with autoclaved dental compound. Prior to closure of the primary incision, a sheet of tantalum foil, .00025 inches thick, is placed over the defect and extending well beyond the ledge. Repeated experience with this method has shown that this is an important step in this technic of repair, since at the secondary operation for the insertion of the plate, the skull defect and adjacent bone will be found uninvolved in scar tissue and not adherent to the overlying scalp. The tantalum plate, formed from the direct impression, will need no adjustment at secondary operation and the procedure may be carried out expeditiously at any time deemed advisable during convalescence. (See Case 2)

TANTALUM CRANIOPLASTY IN FRESH WAR WOUNDS

In addition to the more refined methods of cranioplasty that have been described, other methods are available for the repair of skull defects involving relatively uncomplicated skull contours. These include the preforming of plates upon a basic model of the skull, with the only individual variation being the size of the plate, the "hammering" of plates with the aid of preformed plaster molds and the preparation of plates at the operating table by "hammering." Fixation methods include the simple onlay of the plate or inlay of the plate in a ledge, springing of the plate in a ledge,[26] wiring,[23] or minor variations in the preparation of the ledge or the use of V-shaped prongs formed as part of the plate and driven into the outer table of the skull as a method of fixation. None of these methods is applicable to the repair of deforming, complicated frontal defects.

Onlay tantalum plates, secured with wire sutures, or inlay plates secured with tantalum wedges, with the plates hammered out at the operating table, may have a place in the cranioplasty of fresh war wounds, and the principles involved may be used in fresh civilian wounds of the skull. Immediate cranioplasty of this type is only possible because of the lowered incidence of infection secondary to penicillin therapy and should be reserved for those cases without dural penetration. This procedure must still be considered to be in a stage of clinical trial, representing one of the efforts to hasten the convalescence of military casualties. The following case report illustrates a pioneering effort in this direction:

Case 4.—Reg. No. 219533, Walter Reed General Hospital. R. W. D., age 21, was injured in France at 1030 hours, July 26, 1944, by the tree-burst of an 88-millimeter shell. He sustained a penetrating wound of the vertex of the skull, the shell fragment traversing his helmet and causing a compound, comminuted fracture of the left parietal bone adjacent to the sagittal sinus and also involving the right parietal bone. He was unconscious for ten minutes and upon regaining consciousness, noted motor and sensory paralysis of both lower extremities. The right lower extremity improved steadily during the next 90 minutes. Sulfonamide therapy, local and general, was continued during evacuation to England. On July 29, 48 hours after injury, débridement of scalp and bone was performed, with removal of a small extradural hematoma. The dura was intact and was not opened. The outer table of the skull about the circumference

of the bony defect was removed, forming a ledge upon which a "hammered" plate was laid and fixation secured by tantalum points. Penicillin was given locally and parenterally, and wound healing was normal.

At the present writing, the patient shows a mild spastic monoplegia, with diminution in cortical sensibility in the left lower extremity. The electro-encephalogram is normal and the cranioplasty is technically above criticism.

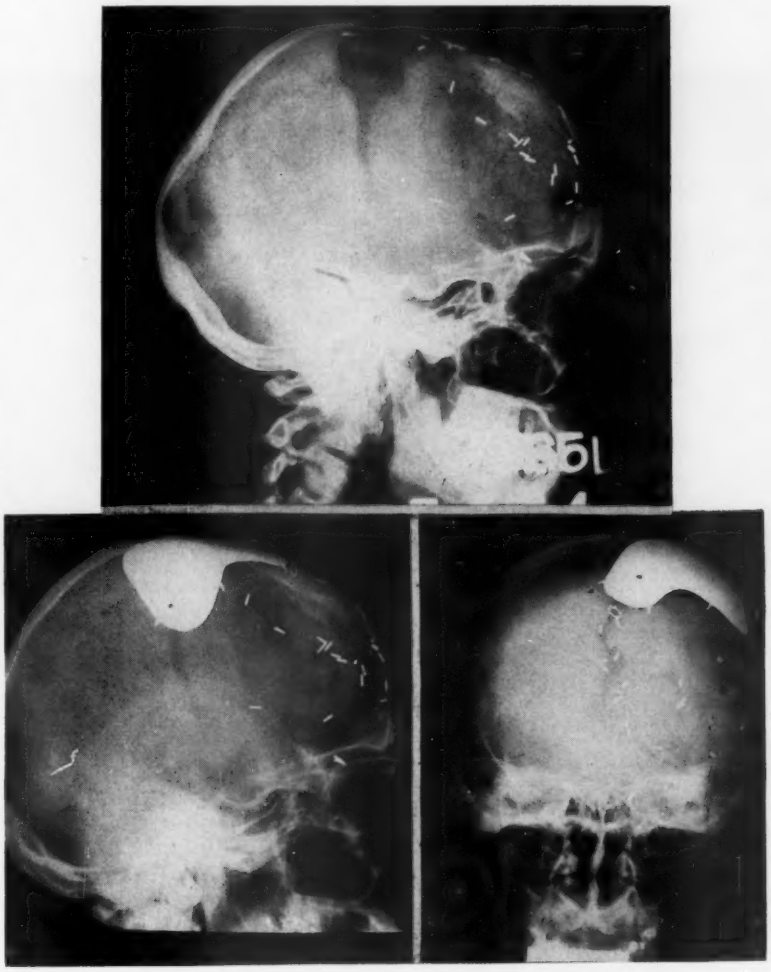

FIG. 8.—Case 4: Roentgenograms of skull defect following craniotomy for tumor and subsequent tantalum cranioplasty and wire fixation of remaining bone plate.

ANALYSIS OF 79 CASES OF TANTALUM CRANIOPLASTY

In a previous report,[23] several massive tantalum cranioplasties have been reported in an effort to illustrate the utility and simplicity of the operative technic and the facility with which the element may be adjusted to any type of repair. Similar unusual cases have been reported elsewhere,[7, 26] We wish to emphasize the fact, however, that the majority of skull defects

resulting from war wounds are relatively uncomplicated problems. This fact, added to the essential inertness and malleability of the element and the technical ease of its insertion, makes tantalum cranioplasty a procedure available not only to trained neurosurgeons but to military surgeons as a whole. Pertinent analyses of the cases we are reporting may be summarized as follows:

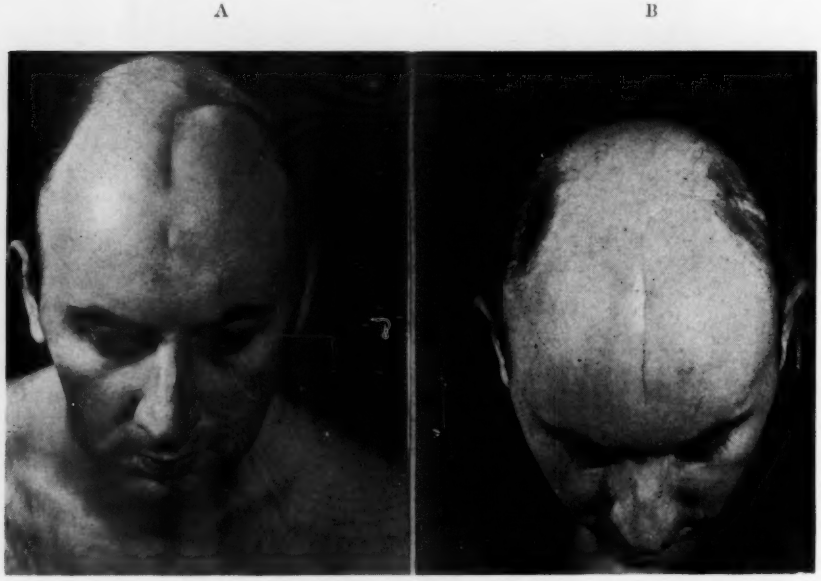

FIG. 9.—Case 4 (A) Irregular skull defect following craniotomy for tumor. (B) Cosmetic result following tantalum cranioplasty.

LOCATION OF DEFECT					
Right frontal	12	Left frontal	18	Bifrontal	7
Right temporal	5	Left temporal	6	Biparietal	3
Right parietal	8	Left parietal	10	Bioccipital	3
Right occipital	3	Left occipital	4		13
	28		38		

The predominance of left-sided injuries is probably not of statistical significance but in this particular series of cases has exerted some influence on the character of the posttraumatic neural defect.

CAUSE OF INJURY			
Shell fragment	48	Osteomyelitis	2
Vehicle accident	6	Mine explosion	1
Blow	4	Aerial torpedo	1
Rifle bullet	4	Bayonet	1
Machine pistol bullet	3	Propeller blade	1
Machine gun bullet	3	Dynamite explosion	1
Craniotomy	3	Horse kick	1

The majority of skull defects are caused by shell fragments. This fact would suggest a failure to survive the impact of the higher velocity missiles of

rifle and machine gun. This point can only be judged with the aid of active theater military pathologists.

ASSOCIATED WITH PERMANENT NEUROLOGIC DEFECT

Hemiplegia	9
Unilateral loss of vision	8
Hemiplegia and aphasia	6
Aphasia	5
Bilateral loss of vision	5
Mental retardation	2
Hemiplegia and loss of vision	1
Monoplegia	1
Homonomous hemanopsia	1
	38

The character of the residual neurologic defect, observed at an average time of four months after injury, has been described in rough terms that serve to indicate merely the usual forms of permanent injury, the potential percentage of severe sequelae and their influence upon disposition to duty.

INDICATIONS FOR CRANIOPLASTY AND THE RELIEF OF SYMPTOMS

A statement concerning the indications for cranioplasty with particular reference to the influence of the factor of return to duty has already been made. We have not analysed in detail local or subjective symptoms presented by our patients. We have been impressed, however, by several points that deserve comment.

The majority of our patients have noted localized tenderness upon palpation of the area of the defect, and have complained of localized pain that has had a tendency toward spontaneous resolution. These subjective complaints have been benefited by cranioplasty. Vertigo and generalized headache are less common complaints and appear unaffected by cranioplasty. They represent, in all probability, the sequelae of the cerebral injury. In the same category rests the complaint of tingling paresthesias in upper or lower extremities and chest wall occasioned by a rapid and pronounced flexion of the cervical spine and unaffected by cranioplasty.

The number of repulsive or deforming defects is measured by those involving the supra-orbital and frontal regions of the skull rostral to the hair line. When associated with unilateral or bilateral loss of the orbital contents, they represent cosmetic disorders that demand improvement. The combination of tantalum cranioplasty and the insertion of appropriate orbital prostheses has given gratifying results.

A study of this series of cases has presented at least a partial answer to the problem whether or not any form of cranioplasty may influence an underlying convulsive state. Observations of the effect of cranioplasty upon changes in electrical activity of the brain have been made in 26 cases studied before and after cranioplasty over a varying time period from 4 to 12 months.[5] Identical records may be obtained before and immediately after tantalum cranioplasty, and it is obvious that the tantalum itself has no

influence upon the technic of this examination. In these 26 cases, 12 showed no subsequent change in the character of cortical electrical activity, in ten there was evidence of improvement in an abnormal electro-encephalogram and in four the abnormal activity became even more manifest, with the development of epileptogenic foci. Cranioplasty was not performed upon patients whose convulsive state had not been controlled by conservative measures and thus far, there has been no opportunity to judge the direct effect of cranioplasty upon an uncontrolled convulsive state. The excision of the concomitant cerebral scar will always invalidate such a trial. Studies upon additional cases have not altered these impressions.

DISPOSITION TO DUTY OR OTHER STATUS

Discharged or retired for physical reasons:	
Neurologic defect	28
E.E.G. epileptogenic focus	6
Convulsions	5
Other contributing factors	4
	43
Discharged from hospital to duty	36

POSTOPERATIVE COMPLICATIONS

Infection	2
Plate slipping (early case)	1
Extradural pneumatocele (frontal sinus)	1
	4

The Value of Complementary Pneumo-encephalography.—We have not been impressed by the value of pneumo-encephalography in the estimation of the degree of concomitant cerebral injury when compared to the aid derived from a carefully reviewed history, from the neurologic examination and, in particular, from repeated electro-encephalographic studies. Only 18 air studies have been conducted in these patients, the majority in those exhibiting convulsions or an epileptogenic focus. They have added nothing but confirmative evidence to less distressing methods of examination and appear to hold a minor place in the survey of a relatively fresh injury. With the use of multiple projections, the insertion of a tantalum plate, unless it be of massive size, need not detract from the future application of this method, in those cases in which resection of a cerebral cicatrix may be indicated.

ILLUSTRATIVE CASES

Case 5.—*Midfrontal defect, aerial torpedo wound on November 27, 1943. Tantalum cranioplasty, indirect, primary method on June 29, 1944. Adequate cosmetic result.*

J. K., Reg. No. 215697, Walter Reed General Hospital, age 32, was injured on a troop transport by fragments from an aerial torpedo. There was no loss of consciousness nor evidence of neurologic defect. He was lowered over the side of his ship and floated about for several hours before being rescued by a friendly mine-sweeper. Débridement and primary closure of a midfrontal, compound, comminuted fracture of the skull with cortical laceration was carried out 48 hours after injury by a British installation. Wound healing was normal. There was no history of convulsions. He was received at this hospital on June 17, 1944. He had no complaints and the neurologic examination was

normal. There was an irregular skull defect in the midfrontal region, rostral to the hair line, and involving the medial and superior margins of both supra-orbital ridges, more so on the left. Roentgenograms more clearly define the extent of the defect. The preoperative electro-encephalogram showed bursts of fast activity, 14-22 per second, in both frontal leads. Spinal air injection disclosed a normal ventricular system and subarachnoid space. Tantalum cranioplasty through a coronal scalp incision with reflection of the rostral flap disclosed the skull defect. A well-contoured, preformed tantalum plate was inlayed in the usual bony ledge and fixation was secured with tantalum wedges. An adequate roentgenographic and cosmetic result was obtained (Figs. 3, 4 and 5).

This particular defect and the method of repair may be considered as fairly typical of the majority of cases in this series.

Case 6.—*Left frontal skull defect, caused by shell fragment injury on January 6, 1944, associated with loss of left orbital contents and intra-orbital cerebral fungus. Meningitis. Resection of fungus, dural graft and control of subarachnoid infection. Tantalum cranioplasty, direct, secondary method, on June 1, 1944, and transfer to Ophthalmological Center.*

L. P. D., Reg. No. 213526, age 22, was struck by shell fragments in the left frontal region and in the left orbit on January 6, 1944. He was semicomatose for the first 24 hours and during this time the left orbital contents were exenterated and a compound, comminuted fracture of the left frontal bone, frontal sinus and orbital plate was débrided and closed. His convalescence was smooth and after return to the Zone of the Interior, he was sent to an ophthalmologic center for an orbital prosthesis. On May 7, he developed fever, cervical rigidity and rapidly became stuporous. Lumbar puncture demonstrated a sterile pleocytosis of 835 cells, half of which were polymorphonuclear in type. The acute meningeal infection was controlled readily with daily injections of 10,000 units of penicillin in the lumbar subarachnoid space. Review of the overseas record suggested the possibility of an intra-orbital cerebral fungus. On June 1, 1944, a coronal scalp flap was reflected rostrally exposing the bony defect. A yellow, scarred mass of necrotic cerebral tissue filled the orbit. This mass of tissue was resected until the margins of a triangular dural defect were visualized. An appropriate-sized area of pericranium was placed over the defect and held in place by a thin disk of fibrin foam, impregnated with penicillin. The customary ledging of the edge of the bony defect was made, the mold for the proposed tantalum restoration taken, and the defect and the adjacent ledge were covered with tantalum foil, .00025 inches thick. The coronal flap was then closed with galeal and scalp interrupted sutures of fine nylon.

Twenty-five days later, the former coronal suture line was reopened and the protecting tantalum foil removed. The operative field was quite clear of scar tissue and not adherent to the scalp. Tantalum cranioplasty was promptly accomplished. This patient has been returned to an ophthalmologic center for plastic revision of the eyebrow and upper lid and for the orbital prosthesis to complete his rehabilitation (Figs. 6 and 7).

Case 7.—*Frontal sinusitis, left, on August 26, 1943. Extradural abscess, osteomyelitis, left frontal bone. Left frontal brain abscess. Resection of brain abscess in December, 1943, after previous resection of left frontal bone. Recovery with tantalum cranioplasty on March 2, 1944.*

C. B., Reg. No. 200710, Walter Reed General Hospital, age 23, while training, developed an acute left frontal sinusitis on August 26, 1943. Drainage of this infection was followed by osteomyelitis of the left frontal bone and an extradural abscess. Resection of the involved bone was carried out on September 21, 1943. His convalescence was protracted, and following the development of stupor and electro-encephalographic localization of a focus in the left frontal lobe, an intracerebral abscess was at first aspirated and later enucleated in December, 1943. All procedures were protected by

penicillin administered by appropriate routes. On March 2, tantalum cranioplasty restored the normal skull contour of the left frontal region (Fig. 8).

Case 8.—*Craniotomy for left parasagittal tumor on December 3, 1943. Postoperative infection controlled by penicillin, with partial loss of craniotomy flap. Convulsive state, with marked anxiety concerning pulsating defect. Tantalum cranioplasty on June 29, 1944, with relief of subjective disturbances and mental rehabilitation for reëntry into civilian status.*

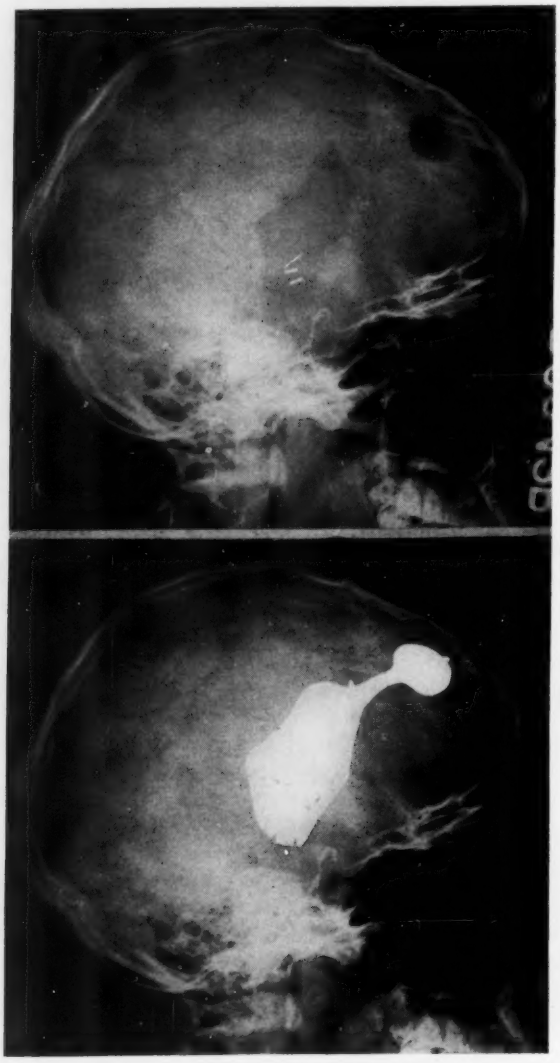

FIG. 10.—Roentgenograms of multiple skull defects following operation for subdural hematoma and following subsequent tantalum cranioplasty.

H. M. F., Reg. No. 214687, Walter Reed General Hospital, age 31, developed headache, vomiting, impairment of vision, indifference and slow cerebration while overseas, with rapid progress of symptoms and neurologic signs suggesting a left frontal lobe tumor.

A technically difficult resection of a left frontal lobe parasagittal meningioma was accomplished on December 3, 1943, necessitating further bone resection for exposure of the tumor. His convalescence was interrupted by a wound infection, readily controlled by penicillin. An intermittent convulsive state was aided with conservative measures following his evacuation to the Zone of the Interior. There was an extensive frontal alopecia and the patient developed an anxiety state, centered upon the obvious deformity and the fear of injury to the pulsating defect. On June 29, 1944, tantalum cranioplasty corrected the deformity and stimulated favorably his rehabilitation to civilian status. Restoration of much larger postcraniotomy defects have been reported[7, 26] (Figs. 9 and 10).

Case 9.—*Blow in right temporal region on February 14, 1943. Gradual onset of increasing intracranial pressure with evacuation of a chronic subdural hematoma on March 30, 1943, through a subtemporal decompression opening following two exploratory trephines. Tantalum cranioplasty on September 7, 1943.*

D. A. A., Reg. No. 198922, Walter Reed General Hospital, age 24, was struck with a beer bottle in the right temporal region on February 14, 1943. He sustained a closed head injury and was unconscious for two days. His recovery was protracted and never complete. He continued to complain of headache and developed diplopia, left-sided motor weakness and papilledema. On March 30, 1943, a chronic subdural hematoma was evacuated in another hospital. Following a smooth convalescence, he developed pain in the pulsating skull defect. Spinal air injection studies and electro-encephalography were normal. On September 7, 1943, a gooseneck tantalum plate was inserted effectively protecting the irregular decompression opening and a tender rather large, frontal trephine opening (Fig. 11).

A minor technical point is to be noted in the accompanying illustration. The thin squamous portion of the temporal bone does not allow wiring readily nor does it permit ledge formation. In this area, primary fixation of a tantalum plate may be obtained by alternating small, V-shaped wedges of the plate itself, implanted above and below the bone edge. The remainder of the plate is then fixed by any of the methods described.

CONCLUSION

Tantalum cranioplasty has been carried out in 79 skull defects occurring in Army personnel as a result of war wounds and casual injuries. Tantalum possesses two qualities essential for a cranioplastic material, inertness in tissue and strength associated with malleability. Defects involving complicated contours such as those of the supra-orbital ridge are best repaired by the use of preformed plates. The technic of inlay of the plate into a circumferential ledge and fixation by means of tantalum wedges is a simple procedure, widely applicable throughout all Army surgical installations.

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DISCUSSION.—DR. W. J. MIXTER, Boston, Mass.: I have seen a good deal of this work and, as I see it, the use of the tantalum plate is a great advantage to the men in the armed forces. There is no question but what there will be many of these plates used in this war, and we must consider what are the limitations of the procedure and what are its advantages over bone graft, and what is going to be the ultimate result to the patient. In the first place, these plates, particularly if preformed, and particularly if handled in a service which is set up for it, are easy of application. The first one you use in your civilian hospital, never having done this before, will take a long time and you will sweat over it, but after you achieve the technic you will find that you have something so much better and so much easier to handle than grafts that there is no comparison.

As to the limitations of this procedure, I think we will all agree it is very valuable in large defects, but the question arises how far it should be carried in small defects. In civilian life we have paid little attention to many of these small defects. However, in the Army, by using a plate, perhaps two centimeters in size, you can make the patient effective for service, perhaps limited duty, perhaps combat duty. The effect on morale is great. The difficulty will be not in persuading patients to have them put in, but in refusing to put them in for patients who do not need them.

LT. COL. D. HENRY POER, Newton D. Baker General Hospital, Martinsburg, W. Va.: In discussing this most interesting paper I would like to present a preliminary report of the methods being used at the Newton D. Baker General Hospital in dealing with cranial defects. This work is being carried on by Major Charles W. Elkins, of Cleveland, and his associates, and their results have been highly satisfactory.

Since all substances used for cranioplasties are known to have some disadvantages, a more satisfactory one was thought to be necessary and desirable. Since a resin polymer, known as methyl mercrylate or acrylic, could be readily moulded into the desired shape, size, and contour and, being nonmetallic, was not subject to the physical effects incident to changes in temperature, or effects of electrical phenomenon, this substance was selected. Up to the present time, 39 patients have been operated upon without infection or other complication. In the patients requiring accurate maintenance of bony contour such as reconstruction of the supra-orbital ridge, and the nasal bones, a particularly desirable result was obtained. Convulsive seizures followed operation in two patients, but these are in no way considered to be influenced by the substance used for closure of the defect. The largest elapsed time since the earliest implantation is approximately 14 months (Case of Major Joseph Cameron), and there has been no untoward reaction in the tissues. Requiring close coöperation with the dental laboratory, when these moulds are made, it is now possible to perform the entire operation in one stage, using local anesthesia.

It is our thought at the present time that acrylic, or lucite, has certain definite advantages over tantalum, and other materials being used for cranioplasties.

DR. CLAUDE C. COLEMAN, Richmond, Va.: It is interesting to note the changed attitude toward cranial defects. In the early days of surgery for brain tumor, and other expanding lesions, cranial defects were made to give relief of intracranial pressure. The removal of bone in the temporal region, known as "subtemporal decompression" was formerly the principal operation both for tumor and for trauma. Cranial defects, therefore, were not looked upon with any particular disfavor. At the present time the tendency is to keep cranial defects to a minimum and to repair those that are inevitable. In World War I, the repair of defects was the chief cranial operation and there seems to be even more enthusiasm for repair of cranial defects in the present war. It may be this enthusiasm is not entirely justified.

I have been very much interested in tantalum as a material for the repair of cranial defects but until recently this material was not available, and I have had no experience with it in cranioplasty. In the years between the two World Wars, I used celluloid plate and, in my experience, this material for cranioplasty has been entirely satisfactory.* I could not expect better results from any other material. Celluloid is easily molded and thus far I have found it necessary to remove only one plate because of infection. In this case the defect involved the frontal sinus and sufficient time had not been allowed for the patient to recover from the primary infection. The use of celluloid for repair of cranial defects was brought to the attention of this Association by Dr. W. P. Nicolson at a meeting in Pinehurst in 1920.

It appears that the trend now is definitely against autogenous transplants, although a transplant from the outer table of the skull was widely used for repair of cranial defects in World War I. This method, used in army cases at Cape May, was described by me in 1920.† Dr. Joseph E. J. King used grafts from the tibia with satisfactory results.

* Horsley and Bigger: Operative Surgery.. Vol. 2, 4th Ed., p. 1199, St. Louis, C. V. Mosby Co., 1937.

† Coleman, Claude C.: The Repair of Cranial Defects by Autogenous Cranial Transplants. Surg., Gynec. & Obst., 31, 40, July, 1920.

To procure autogenous transplants is a considerable operation, particularly if the outer table of the skull is used. The procedure for obtaining such transplant may be harmful to the patient, requiring as it does a good deal of hammering on the skull.

I dislike to make too many references to the First World War, because I understand I am slated for the Senior List of the Association; however, some reference might be made to what were considered indications for cranioplasty in 1919. All indications were subjective except in those defects which caused conspicuous deformity. The principal complaints of these patients arose from fluctuation of the brain mass through the defect on changing position of the head. This fluctuation caused disagreeable sensations of the head which cranioplasty relieved. It was not believed by those who had experience in World War I that the repair of cranial defects prevented or favorably affected convulsions. Repair of a defect gave a feeling of protection and a sense of security. However, the very small defects, unless producing a deformity, were not repaired. It seems that the indications now for cranioplasty are based largely on the patient's desire for operation. The fact that he desires it seems to be sufficient indication for its performance.

Many cranial defects in civilian practice can be prevented. In all simple depressed fractures of the skull the bone fragments may be replaced and in many compound, depressed fractures if there is not too much contamination and when the operation can be undertaken early.

I was very fortunate in having the opportunity to see some of the cranial defect work at Walter Reed, and other army hospitals. The results of cranioplasty with tantalum plate in the hands of Major Woodhall and others appear to be excellent.

Dr. Joseph E. J. King, New York, N. Y.: I am happy to hear this paper, and to see the splendid results. The use of tantalum plate has a decided advantage over anything we have seen heretofore. Vitallium was difficult to mold and get into shape, and we could do little with it and, therefore, have discarded it. I think this has a decided advantage over any material except probably the celluloid used by Coleman in the enormously large defects that extend in different directions, because you cannot obtain any living transplant to fit well into such defects. As to small defects, I have not seen any objection to the autogenous grafts, except that they are not so easily molded. I have never seen one lost, nor seen any failures since we have used the tibial grafts instead of the thin ones from the outer table, which become absorbed and disappear. I do not think these defects should be repaired if there is any possibility of underlying infection, or in or about the frontal sinus unless the entire sinus has been totally obliterated. I cannot accept putting either bone or metal in unless all mucous membrane and cavity have been eliminated. With missiles buried in the brain I see no point in performing any type of cranioplasty unless the foreign body is removed.

Several years ago, Dorothy Klenke removed the bone from a flap in the first stage of an operation for what was thought to be a malignant underlying tumor. But when she opened the dura a few days later it proved to be a meningioma. So there was a large defect. One of the boys remembered he had taken the bone over to the laboratory, so he brought it back. She perforated it several times in a pepper-box manner with a small drill, put it back in place, and had perfect healing—with bone that had been discarded four days before.

In osteomyelitis, as shown by Furstenberg, and others (and in my personal experience), there is no need of repairing these postoperative defects if the dura is intact and the pericranium has been turned down and is later approximated against the dura. I have never seen one that failed to repair itself in two or three years, more rapidly in children than in adults.

Dr. John W. Price, Jr., Louisville, Ky.: I cannot resist the temptation to express my appreciation of this splendid work that is being done by neurosurgeons in this war. As one of Doctor Cushing's boys in the last war, I feel that I can speak with some authority on what we had. I did the brain work in Evacuation Hospital No. 7 and No. 15, and in the mobile hospitals, and what Major Woodhall said about these defects being the result of mine accidents principally, and not machine gun bullets, bears out our experience. We did not have so many cases come back to the United States after they got into our evacuation hospitals, yet a few did come back. But the marvelous

work this group is doing today I think is a monument to the early training of the brain surgeons, which has been going on for the past forty years.

DR. ALTON OCHSNER, New Orleans, La.: This marvelous element was first worked on by John Bu[illegible]h a member of the Southern Surgical Association, at Vanderbilt University. So I think we should be proud of him.

I would like to ask whether there is any danger of heat absorption from the implantation of this metal. There have been some reports of this.

MAJOR BARNES WOODHALL, Washington, D. C. (closing): We have invested a considerable amount of the well-being of our soldiers in this type of cranioplasty. Some of our colleagues in other fields of endeavor have carried out intensive studies on the influence of cold and heat and electrical fields upon these plates. So far as I know, individuals with tantalum plates do not react adversely to these influences under normal conditions of living. However, we would be derelict in our duty if we did not have another type of cranioplasty up our sleeves, as it were, in case tantalum cranioplasty should fall down under some unforeseen influence; I am, therefore, grateful to Colonel Poer for discussing acrylic cranioplasty. We have seen the majority of cranioplasties turned out by this method and there is no doubt but that the cranioplasty, so far as results are concerned, is beyond reproach. I feel, however, that the technic is more difficult in complicated cases and, in addition, the synthetic resins are not malleable and a two-stage procedure is always necessary.

In response to Doctor Coleman's remarks, may I say that the neurosurgical centers would be greatly weakened if we did not have the constant aid and comfort of what he calls the senior neurosurgeons.

PENICILLIN AS AN ADJUNCT TO THE SURGICAL TREATMENT OF ACUTE AND CHRONIC EMPYEMAS*

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THE INTRODUCTION of any therapeutic agent which may control infections is received with enthusiasm by both surgeons and internists. The former anticipates reduction and perhaps elimination of postoperative infections. The latter hopes that surgical intervention will no longer be necessary.

The astonishing results which have been obtained with penicillin have naturally revived interest in the nonsurgical treatment of empyema and also stimulated investigations on the value of the agent as an adjunct to surgery.

Optimistic reports are already recorded in the literature on the treatment of postpneumonic empyema by local and systemic administration of penicillin. For example, Tillett, Cambier and McCormack[1] report eight cases of pneumococcal empyemas treated by intrapleural injections of penicillin. In seven, the infection was eliminated; six patients recovered completely; and only one patient was operated upon. Keefer[2] and his associates have recorded successes in sterilization of empyema cavities by local penicillin therapy. Bennett and Parkes[3] describe four more penicillin cures of empyema, and are hopeful that the necessity of surgery for suppurative pleurisy will be largely eliminated by the use of penicillin. Undoubtedly, as penicillin becomes generally available, more successful nonsurgical cures of empyema will be described.

PENICILLIN IN THE TREATMENT OF ACUTE POSTPNEUMONIC EMPYEMA

Twenty-four patients considered to have acute empyema and originally treated with penicillin have been studied on the Thoracic Surgical Section, Walter Reed General Hospital. Twenty-one of these cases were transferred to a general hospital after treatment was begun. The amount of penicillin given, the methods of administration and the time factors varied considerably in this group. Thirteen patients received both intramuscular and local penicillin therapy. Six patients received systemic administration of the drug alone. In five cases, only local penicillin therapy was employed (Tables I, II, and III). The bacteriologic details are not important except to state that in all but two cases the infections were caused by penicillin-vulnerable organisms.

Penicillin Cures.—Three patients escaped drainage operations. In one case only intramuscular penicillin was given. Both intramuscular and intrapleural routes of administration were employed in the other two patients who recovered without surgical intervention.

* Read before the Fifty-sixth Annual Session of the Southern Surgical Association, December 5–7, 1944, Hot Springs, Va.

Critical analyses of these cases reveal that in two patients in whom repeated aspirations and penicillin therapy were credited with effecting a non-surgical cure of empyema, the fluid was infected but did not thicken to form gross pus. It is obvious, therefore, that a true abscess had not formed and the empyemas were not cured but were aborted.

TABLE I

COMBINED SYSTEMIC AND LOCAL PENICILLIN—13 CASES

Pleural fluid sterile	10 cases
Penicillin cures	2 cases
Chronic empyema	1 case
Thoracostomy	11 cases

RESULTS IN 13 CASES OF ACUTE POSTPNEUMONIC EMPYEMA TREATED WITH BOTH INTRAMUSCULAR AND INTRAPLEURAL PENICILLIN INJECTIONS. ELEVEN REQUIRED SURGICAL DRAINAGE.

TABLE II

INTRAMUSCULAR PENICILLIN—6 CASES

Pleural fluid sterile	2 cases
Penicillin cure	1 case
Chronic empyema	1 case
Thoracostomy	5 cases

RESULTS IN SIX CASES OF ACUTE EMPYEMA TREATED WITH INTRAMUSCULAR PENICILLIN ALONE. IT IS INTERESTING THAT THE PLEURAL FLUID BECAME STERILE IN TWO CASES.

TABLE III

LOCAL PENICILLIN—5 CASES

Pleural fluid sterile	5 cases
Chronic empyema	1 case
Thoracostomy	5 cases

A SUMMARY OF THE RESULTS IN FIVE CASES TREATED WITH ONLY INTRAPLEURAL INJECTIONS OF PENICILLIN. THE PUS IN THE EMPYEMA CAVITIES BECAME STERILE IN ALL CASES, BUT THICKENED AND REQUIRED SURGICAL DRAINAGE.

In only one "penicillin cure" thick creamy pus was found in the pleura. Cultures revealed *beta Streptococcus* and *Staphylococcus albus*. Intrapleural injections of penicillin were given over a period of 24 days with two initial doses of 100,000 units followed by three injections of 40,000 units. Cultures of the pus were sterile after the first injection of penicillin. Over 5,000 cc. of pus was removed by aspiration. Eleven thoracenteses were performed. Intramuscular penicillin therapy was continued for five months. A condition which could have been cured by adequate surgical drainage in from 30 to 60 days was prolonged for five months and during all of this time the patient was exposed to the calamity of the development of a chronic empyema.

Chronic Sterile Empyemas.—Three patients developed chronic sterile empyemas while on penicillin therapy. In two instances, the complications were the direct results of delayed drainage of an empyema cavity containing thick sterile pus. The third case was complicated by a bronchopleural fistula. There is no question that penicillin therapy was of tremendous value in controlling a concomitant streptococcal pneumonia in this patient. The development of a chronic empyema was not influenced by chemotherapy.

SUMMARY.—Our observations indicate that when suppurative pleuritis is caused by penicillin-vulnerable organisms, intrapleural injections of the drug will temporarily sterilize the pus. If the pus continues to thicken, however, it is usually necessary to perform surgical drainage to evacuate the material. If this is not done, a chronic empyema may develop and regardless of the sterility of the pus, the same problem of cavity obliteration remains to be solved.

As experience with penicillin therapy accumulates, the therapeutic approaches will become more standardized. Based upon our own observations, a tentative plan for the use of penicillin as an adjunct to the surgical treatment of acute empyema is suggested: 1. An injection of 50,000 units of penicillin may be given intrapleurally as soon as an infected fluid appears in the pleural cavity. It is important that treatment be withheld until the organism is positively identified. This precaution will prevent waste of penicillin in infections which do not respond to the drug, and an initial bacteriologic diagnosis will also rule out the possibility of a tuberculous effusion or empyema. 2. If systemic penicillin has been employed during the pneumonic stage of the disease, we believe it should be combined with local therapy. It is admitted that in many instances the pneumonic phase will have subsided by the time an empyema becomes apparent. The advantage of the systemic route, however, is that the blood will contain an antibacterial inhibitory substance which may control spreading cellulitis or invasive infection. It is our opinion, therefore, that systemic administration of penicillin should always be combined with local therapy. This is particularly true in cases of streptococcal and staphylococcal empyemas. Probably three intrapleural injections of 50,000 units on alternate days is sufficient for local treatment. Before the penicillin is injected into the pleura, as much of the infected fluid as possible should be removed by thoracentesis. If the pus continues to form and thickens, surgical drainage should be established. Temporary or even permanent sterilization of the pus does not alter the most important fundamental surgical principle in treating empyema thoracis, namely, adequate drainage.

PENICILLIN IN THE TREATMENT OF CHRONIC EMPYEMA

Systemic Administration.—After adequate drainage of a chronic empyema cavity has been established, it appears that neither the local nor systemic administration of penicillin is important. During the period of observation to determine whether the cavity will become obliterated without further surgical intervention, there is little danger of spreading cellulitis or invasive infection. Continued fever and failure to gain weight and other manifestations of sepsis usually mean an undrained or inadequately drained collection of pus. No chemotherapeutic agent can be depended upon to replace proper drainage when dealing with pyogenic abscesses.

Local Penicillin.—Until penicillin becomes as plentiful, and as inexpensive as Dakin's solution, azochloramid or even physiologic saline, its use as an

irrigating agent in drained abscess cavities will not be practical. Frequent irrigations with penicillin may eliminate from cultures penicillin-vulnerable organisms, but other common bacteria will persist. In five cases, daily irrigations of 25,000 units of penicillin were given for a period of ten days. In another six cases, both local and systemic penicillin were employed. Control cases with similar infections and approximately the same-sized empyema cavities were irrigated with Dakin's solution, azochloramid and saline. There were no significant differences in the time required for healing, and cultures from the cavities revealed a similar variety of organisms in all cases. The prevailing organisms were *B. proteus, B. aerogenes,* sometimes *staphylococcus,* occasionally *Streptococcus faecalis* and *nonhemolytic Streptococcus.* Cultures on different days revealed different bacteriologic patterns.

There are many disadvantages when penicillin is used for irrigations. To be effectual at all the agent must remain in contact with the tissues for some time. It is necessary, therefore, for the patient to remain in bed in the same position for several hours, so that the fluid will not be lost from the cavity. Irrigations at frequent intervals are precluded because of the extravagant amounts of penicillin which would be necessary.

Our experiences suggest strongly that the principal benefits of irrigations result from the mechanical cleansing of the cavity and not from any chemical or specific antibacterial effect of the irrigating agent.

Probably the most valuable rôle of penicillin in the treatment of chronic empyema is the protection which it may afford against spreading infection when a radical operation is undertaken for the obliteration of a chronic empyema cavity. When it is used as a prophylactic agent for this purpose, it is impossible to make a precise evaluation of its benefits. It seems reasonable, however, that when one is working through an infected or potentially infected field, penicillin protection may often prevent serious wound infections and other complications.

PENICILLIN AS A PROPHYLACTIC AGENT FOR THE PREVENTION OF POSTOPERATIVE EMPYEMA IN CASES OF LUNG RESECTION

Since postoperative empyema is the principal cause of both mortality and morbidity after resection of lung tissue, it is reasonable to utilize penicillin in an effort to reduce the incidence of this serious complication. When the mold first became available in limited quantities, we employed it in cases of empyema following pulmonary resection and were disappointed with the results. Penicillin was given both systemically and locally, and there was no positive evidence in six cases so treated that it had an appreciable effect upon the infection.

Recently, we have had an opportunity to utilize penicillin as a prophylactic agent in patients subjected to lobectomy for suppurative diseases of the lungs. Before enumerating our results it is important to consider a portion of White's[4] report on a carefully performed clinical research project on the

same subject. This study was under the supervision of Lockwood and Rhoads in connection with the activities of the Committee on National Research of the Office of Scientific Research and Development. They found that penicillin was of greatest value in cases of suppurative pulmonary infections. In 21 patients who had partial or total lung resection for bronchiectasis or multiple lung abscesses, ten cases subjected to lobectomy and two cases treated by pneumonectomy were given prophylactic injections of penicillin. Penicillin therapy was begun seven days before the operation and continued for two weeks postoperatively in doses of 150,000 units daily. Penicillin was not applied directly into the pleural space at the time of operation. The control group consisted of seven lobectomy cases and two patients upon whom pneumonectomies were performed. None of the patients receiving penicillin developed evidence of intrapleural infection. All of the control group developed empyemas and three of them died as a result of infection.

Our studies on the value of penicillin as a prophylactic agent in the prevention of empyema following pulmonary resection for suppurative disease of the lung are not strictly comparable to those reported by White. Penicillin was started at varying intervals before the operations, and all cases receiving prophylactic intramuscular injections of penicillin also had 25,000 to 50,000 units of the agent placed in the wound at the time of operation. The cases were not as carefully grouped as in White's studies, but the variety of lesions are approximately the same in the treated and in the control series.

Thirteen of the patients in the treated group received penicillin the day of operation. Seven patients received intramuscular injections 24 hours before the operation. In two cases penicillin was given for three days before surgical intervention; for five days in two other cases; and for seven days in three others. Two patients had been on penicillin treatment for three weeks before lobectomy was performed. In all instances the dosage was 25,000 units intramuscularly at three hour intervals. Penicillin was continued after the operation until the temperature was normal and the remaining lung tissue was fully reëxpanded and the wound solidly healed.

The length of time penicillin was employed preoperatively did not appear to influence the development of postoperative empyemas. For example, the two patients who received the drug for three weeks before operation developed empyemas. Both had pulmonary resections for chronic lung abscesses. The incidence of empyema in cases treated from three to five days preoperatively was approximately the same as the patients started on penicillin protection 24 hours before surgical intervention.

Summaries of the results in the treated group and in the control group are shown in Tables IV and V.

It is apparent that the incidence of empyema is approximately the same in the two groups. There was one death in the series of 59 cases which possibly could have been avoided if penicillin had been available. It is interesting to note that in all patients subjected to pulmonary resection for

TABLE IV

PENICILLIN-PROTECTED—PULMONARY RESECTION

Lesion		Empyema	Escaped Empyema
Lung abscess	2	2	0
Cystic disease	6	4	2
Bronchiectasis	21	5	16
	29	11	18

SUMMARY OF THE INCIDENCE OF POSTOPERATIVE EMPYEMA FOLLOWING PULMONARY RESECTION IN CASES WHICH HAD RECEIVED PENICILLIN PROTECTION.

TABLE V

CONTROLS—PULMONARY RESECTION

Lesion		Empyema	Escaped Empyema
Lung abscess	3	3	0
Cystic disease	7	3 (one death)	4
Bronchiectasis	19	6	13
Coccidioidal cyst	1	0	1
	30	12	18

RESULTS IN 30 CASES OF PULMONARY RESECTION WHICH DID NOT HAVE THE BENEFITS OF PENICILLIN THERAPY.

chronic lung abscess a complicating empyema developed. However, empyema was avoided in a rather large percentage of cases operated upon for bronchiectasis. This finding corresponds with our experiences when the sulfonamides were employed in an effort to prevent postoperative empyemas and was true even before chemotherapeutic agents were available for this purpose. It is our impression that in our series of cases the incidence of empyema depended entirely upon successful closure of the bronchus. If the bronchus opened early during the postoperative course, a serious empyema developed. If it did not, empyema was avoided, or if it did develop after the remaining lung had reëxpanded it was not serious. The only other justifiable conclusion from this study is that penicillin does not guarantee absolute protection from postoperative empyema in cases subjected to lung resection.

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DISCUSSION.—COL. I. MIMS GAGE, Atlanta, Ga.: The edited transcript was not received in time for publication. If it is received before the "Transactions of the Southern Surgical Association" is published, it will appear therein.

DR. FRANK K. BOLAND, Atlanta, Ga.: I should like to express my endorsement

of the remarks of the two previous speakers on penicillin as an adjunct. At the colored division of the Grady Hospital in Atlanta, Dr. Paul Beeson recently has treated 15 cases of acute empyema with injections of penicillin into the abscess cavity, and apparently has cured ten cases without surgical operation. Eight of these followed pneumococcal pneumonia, and two were the result of stab wounds of the chest in which streptococci were found. The success of the treatment seemed to depend largely upon whether or not accessory pus pockets were present.

After aspirating the cavity as free of pus as possible, from 12,500 to 20,000 units of penicillin were injected daily, or every other day, as cultures showed diminished infection. The treatment was necessary for from two to seven weeks before the discharge and fever disappeared. In cases that were operated upon, penicillin was continued as adjunct treatment. We have had no experience in treating chronic cases, but all surgeons must welcome the addition of any agent which will cure or help cure intractable chronic empyema.

At the present time penicillin is achieving remarkable results in medicine and surgery, but one or two years is not long enough to appraise its permanent therapeutic value. We should be slow to adopt exclusively any method of treatment as a substitute for good surgery.

DR. JOHN S. LOCKWOOD, New Haven, Conn.: I think Doctor Blades is to be congratulated on having prepared this report based on experience in army hospitals, because it is to the army hospitals we must look for experience right now.

Our experience in the use of penicillin in treatment of pneumococcic empyema has tended to support the fact that where the organism is susceptible, repeated local injections of 20,000 to 40,000 units of penicillin associated with drainage or aspiration every day, or every other day, will often result in healing of the process, but I would be the last person to advise blind adherence to any form of chemotherapy in empyema. Each case has to be followed as an individual problem. If on the basis of roentgenologic and clinical findings the cavity is collapsing, then one is justified in proceeding with this course of treatment, but if there is evidence that the cavity cannot be evacuated by aspiration, or if the course is not proceeding satisfactorily, one should do thoracotomy and drainage. Pencillin is a help, but is certainly not the whole story, and it would be foolish to pretend that chemotherapy will be the answer in all cases. In multiloculated cases local therapy is not likely to succeed for obvious reasons.

In the failure of penicillin to prevent complications of lobectomy, I am frankly disappointed by Doctor Blades' experience. Our experience in Philadelphia certainly seemed to suggest that the systemic use of penicillin was a real milestone in prevention of complications. It seemed to have no value in tuberculosis or lung carcinoma, but in operations for bronchiectasis and lung abscess it seemed to be of distinct benefit. I do not know how to account for this contrast to Doctor Blades' experience. It may be because the patients in the Philadelphia group always received 150,000 units a day for seven days prior to operation. On the other hand, the favorable results may have been due to the fact that the series was comparatively small. In Doctor White's series there were only ten control cases, and 12 that received penicillin. This is too few to be certain of the statistical significance of the results.

I think it pertinent to point out that empyema which usually follows pneumectomy or lobectomy is usually a polymicrobic process. Many types of organisms may be present, some of which are resistant and some susceptible. As a rule, it is necessary to resort to the usual surgical methods in dealing with these infections once they become established.

Finally, I do believe it worth while to use penicillin in preparing patients with suppurative disease of the lung for operation. I recall one 14-year-old girl, ill for five months, running a septic temperature, and 120 cc. of sputum per day, anemic—no fit subject for operative procedure. She was given penicillin, and within three or four days the temperature was normal and the output of sputum was down to 3 or 4 cc. a day, even with postural drainage. There is no question that she was a better subject for lobectomy than before penicillin was administered. This is not a constant result, but even if only occasional, it is worth while to use penicillin in preparation of patients for surgery, and I believe we can increase the operability of patients with bronchiectasis. When it comes to abscess, with anaerobic bacilli, the results are not so satisfactory, and I do not believe

there is any panacea for treatment of chronic lung abscess, though here again, preoperative preparation with penicillin is rational and should be used.

I would like to close on the note that this is a subject on which there is tremendous need for further investigation. Nobody can offer any dogmatic statement concerning the possibilities of penicillin in pulmonary suppuration. There is ample evidence to warrant its use, but let us not get closed minds and develop any fixed opinion on any single type of treatment.

DR. J. SHELTON HORSLEY, Richmond, Va.: In the ANNALS OF SURGERY, for September, 1944, Colonel Edward D. Churchill has an extremely interesting paper on the use of penicillin in the Mediterranean Area for which he is Consultant. This seems to have superseded to a large extent the various sulfa drugs.

I would like to ask Colonel Blades about the methods of administration of penicillin. An article appeared in the November number of Science* in which the investigators showed that applying ice to the deltoid region an hour before the intramuscular injection, and for a few hours after the injection, delayed very materially the absorption of penicillin so that injections were necessary only about every five or six hours instead of every three or four hours.

LT. COL. BRIAN BLADES, Washington, D. C. (closing): It is important to emphasize that the cases of acute empyema treated with penicillin had, in most instances, been treated elsewhere and referred to a thoracic surgery center after nonsurgical methods had failed I have no doubt that a larger percentage of empyema cases treated by local penicillin may escape surgery than is indicated by our findings.

Perhaps we were a little too radical in providing surgical drainage as soon as frank pus had formed. Our experience with chronic penicillin empyemas, however, made us feel that drainage should be provided if a true abscess of the pleura develops regardless of the temporary sterility of the pus.

There is another factor which makes it difficult to evaluate the results with local penicillin therapy and repeated aspirations; namely, it is impossible to be sure when the empyema is really healed. One cannot measure the cavity and reliance must be placed upon roentgenologic findings. Since a rather large collection of fluid can be present in the chest and not be detected by roentgenologic examination, there is always some danger of a chronic empyema developing in cases thought to be cured by aspiration.

Another important point to be considered is the danger of surgical drainage as compared with the danger of repeated aspirations. The so-called nonsurgical methods are not without danger. For example, in two of the patients in our series penicillin was injected into the lung tissue by mistake during the course of local penicillin and aspiration therapy. It seems reasonable to conclude that if aspiration treatment is carried to the fanatical extremes of 12 or 15 aspirations there will be about an equal chance of surgical accidents as when surgical drainage is carried out for a mature walled-off abscess.

I should like to emphasize that we do not mean to imply that penicillin is not of value as an adjunct to surgery in lobectomy cases. Although, on a statistical basis, our series shows practically no difference, we have no intention of discontinuing the use of penicillin. We feel that the only conclusion to be drawn from our limited experience is that the mold does not afford absolute protection against postoperative empyemas complicating pulmonary resection cases.

In all our cases penicillin was given by the intramuscular route at three-hour intervals. We have had no experience in the method mentioned by Doctor Horsley, namely, chilling the tissues to effect a gradual absorption of the penicillin. In this connection Romansky's work at the Walter Reed General Hospital might be mentioned. He has found that the administration of penicillin in beeswax in peanut oil results in satisfactory blood levels which are maintained for from 3 to 24 hours, depending upon the amount of penicillin given in a single injection. It is our intention to employ this technic in some of our lobectomy cases.

*Trumper, Max (Lt. Comdr.), and Hutter, A. M. (Lt. Comdr.): Prolonging Effective Penicillin Action. Science, 100, 432–434, November 10, 1944.

TOTAL HYSTERECTOMY*

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WHILE HYSTERECTOMY is an operation of a specialized field, it is one which the general surgeon is frequently called upon to perform. Probably the majority of hysterectomies are carried out as part of general surgical practice. For years the procedure was by the supracervical technic, as it still is, in most instances, in the treatment of benign lesions. Many surgeons, however, believe that, when the uterus is removed, whether the lesion be malignant or benign, it is better to extirpate the cervix with it. It is unnecessary to extensively review before this group the arguments in support of the operation as a routine, or to enumerate those raised against it. The subject has become somewhat controversial.

Briefly, it is stated by one school that total hysterectomy should always be performed as it eliminates chronic infectious processes harbored within the cervix and effectually removes the possibility of carcinoma developing in the retained stump. From recent morbidity and mortality figures it is obvious, however, that for the occasional operator, it is better to adhere to the less formidable procedure for routine panhysterectomy, unless one has acquired skill from performing the operation many times, is fraught with danger and carries a higher mortality than the operation in which the cervix is permitted to remain. However, in large clinics where surgeons have perfected a technic in carrying out the procedure, mortality and morbidity are as low as is the case with the less formidable procedure. Under such circumstances, routine panhysterectomy is justified.

In weighing the advantages of panhysterectomy, one must take into consideration the higher incidence of complicating postoperative hemorrhage, damage to the bladder and ureters, cystitis, infection, phlebitis and thrombosis.

There are but two possible benefits afforded the patient by having the cervix removed simultaneously with the body of the uterus. The first is that it circumvents the development of cancer, providing it is not already present, and, second, it removes completely such infectious and inflammatory processes localized in the cervix, the possible precursors of carcinoma yet to appear.

Ward has stated the incidence of cervical stump cancer to be as high as 6.9 per cent. Others report it to be under 1 per cent. The average incidence taken from the figures of 16 different authors who have recently reported on the subject is 2.69 per cent (Table I). It has been thought that cauterization of the cervix, conization, the Sturmdorf operation, etc., would tend to decrease the incidence of carcinoma, possibly completely eliminating it. However, many instances of stump cancer, after such treatment, have been cited.

* Read before the Fifty-sixth Annual Session, Southern Surgical Association, December 5–7, 1944, Hot Springs, Va.

TABLE I

INCIDENCE OF CANCER IN REMAINING CERVICAL STUMP*

Author	Incidence of Cancer of Stump Per Cent
Behney, C. A.	2.15
	4.7
Faehndrich, J.	1.28
Gagey, J.	3.45
Healy, Wm. and Arneson, A. N.	2.6
Hochman, S. S.	1.14
Johnson, C. G. and Tyrone, C. H.	2.2
Kretzschmar, N. R. and Gardiner, S.	1.7
Laborde, S. and Roques, A.	2.9
Martzloff, K. H.—Johns Hopkins Hospital, 1889 to 1917	0.8
Martzloff, K. H.—Collected statistics for The Johns Hopkins Hospital up to 1927	1.7
Meigs, J. V.	1.9
	2.1
	4.0
Scheffy, L. C.	3.6
von Graff	4.1
Mayo Clinic	3.97
Ward	6.00
Richardson	2.3
Average	2.69%

* From Martzloff.

von Graff reporting 37 cases of cancer developing in cervical stumps after partial hysterectomy even after the cervix had been cauterized at the time of the removal of the uterus.

If, as a routine procedure, removal of the uterus *in toto*, notwithstanding these benefits, increases the morbidity and mortality to the extent that it offsets these things, desirable as they may be, then the operation proves to be ill advised, at least in the individual surgeon's hands. If the mortality of total physterectomy is to be greater than that of supracervical hysterectomy plus that of cancer occurring in the cervical stump, obviously the operation should not be performed.

These are truisms which have been set forth so many times that, no doubt, it is a matter of supererogation to again mention them before such an audience. They are referred to merely in connection with the general text of the paper, the chief object of which is to refer to an operation utilized by the author and to report the writer's more recent experiences with it.

Many surgeons conclude that cancer appearing one year or more after operation should be considered as definite evidence that no lesion existed in the cervix at the time of the original subtotal hysterectomy. Others believe, that cancer developing in the remaining stump within three years following the original hysterectomy should be considered as probably existent at the time of the first procedure.

There has been great confusion in reference to this subject. The matter is approached variously and statistical analyses are frequently unreliable. As Martzloff has pointed out: "It is one thing to speak of the incidence of cancer of the cervical stump in relation to cervical cancer in general, and quite

another to speak of the incidence of cervical cancer among cervices left as residua following supravaginal hysterectomy."

In any event, the question of whether or not a total hysterectomy should be performed in the presence of a benign lesion is largely a matter of individualization. The operation should be carried out if a diseased cervix is present or there is a certain prospect of its becoming so, but only if the operation can be performed without undue risk. I cannot accept the opinion that total hysterectomy should never be carried out except in the presence of carcinoma. Neither can I agree with those who advocate total hysterectomy as a routine.

TABLE II

MORTALITY IN HYSTERECTOMY*

Author	Mortality Per Cent Total Hysterectomy Per Cent	Mortality Per Cent Supravaginal Hysterectomy Per Cent
Amreich, I.	6	1.6
Danforth, W. C. 1934		0.28
1941	0.66	0.8
Doederlein	5.5	
Dupertuis, S. M. and Zollinger, R.	2.8	1.7
Faehndrich, J.	4.2	1.5
	6.25	4.5
Franz, K.	3.7	1.6
Fullerton, W. D. and Faulkner, R. L.	4.1	4.2
Kelly-Cullen		5.5
		1+
Kroenig	5.8	
Masson, J. C.	1.2	0.9
Meigs, J. V.	4.4	2.9
Miller, H. E. and Prejean, O.	1.33	2.75
Pearse, R. L.		1.7
Reade, C. D. and Bell, A. C.	3.3	2+
Rinaman, J. C. and Sellers, T. B.	9.6	2.8
Siddal, R. S. and Mack, H. C.	6.4	2.6
TeLinde, R. W.	0	0.15
Waldeyer, L.	2.2	
Weibel	3.5	4.25
Weir, W.	3.1	
Albrecht, H.	3.6	1.9
Doederlein	4.9	4.9
Average	3.87% Average	2.35%

* From Martzloff.

I feel that the weight of surgical opinion is that the total operation is one always of election to be carried out only when it can be skillfully done and with the minimum of morbidity and mortality.

The subject of complete removal of the uterus has excited considerable interest in the past decade, as witnessed by the hundred or more papers published on the subject in that period. From time to time the technic of the operation has been improved. Farrar, Richardson, Masson, and others, have recently described excellent methods.

The average mortality of a large number of operations performed by 22 reporting surgeons was 2.35 per cent for the subtotal operation and 3.57 per cent for total hysterectomy (Table II). With these figures before us, we may be justifiably dubious of the alleged over-all advantages of total hysterec-

tomy. If these average mortality figures are to be those of an individual surgeon, then his course is well defined, and that is to employ only the less formidable procedure.

The operation which the author has employed was described in a recent communication and the results with the first series of patients operated on by the technic was discussed in that paper.[1]

With the last 200 consecutive total hysterectomies performed, the morbidity has been minimum. The patient left the institution on an average of the thirteenth postoperative day. Sixty per cent of the patients were discharged on the twelfth postoperative day. All recovered.

The conditions for which the operation was carried out were:

Fibroids	147	72.77%
Carcinoma of fundus or cervix	26	12.87%
Endometriosis	11	5.44%
Carcinoma of ovary	3	1.48%
In conjunction with removal of ov. cysts	9	4.45%
In addition to abdominoperineal resection for carcinoma of the rectum	1	.49%
Mis. pathologic processes	5	2.47%
	202	

CONCLUSIONS

It may be assumed that the incidence of true residual cervical stump cancer is about 2 per cent. Therefore, if one can constantly keep one's mortality well under 2 per cent, with no increase in operative complications, then is one justified in carrying out the complete operation. If one's mortality is consistently greater than that expressed by an average irreducible minimum plus the percentage incidence of cervical stump cancer, then one's course is clear enough, and the subtotal operation should be performed. The question of what procedure to elect resolves itself into a matter of what one's consistent results are as expressed in morbidity and mortality experiences.

DISCUSSION.—DR. E. H. RICHARDSON, Baltimore, Md.: I doubt very much if most of the members of this Association realize from the splendid manner in which Doctor Foss has presented his paper, that in the American Gynecological Society this subject is almost as controversial as that of disks seems to be here. There is a sharp difference of opinion among leading gynecologists in the country regarding routine total hysterectomy for benign disease when the cervix is normal. There is no controversy as to the desirability of routine total hysterectomy when the cervix is diseased, but with a normal cervix I can see no reason for the more radical operation, and I have not yet found in the literature a convincing argument that justifies it. Moreover, I think it is dangerous teaching to present statistics on hysterectomies which convey the impression that total ablation of the uterus is a simple easy procedure that can be carried out by the average surgeon. I have not time to expose the fallacy inherent in such statistics, nor to emphasize the fallacy pointed out by Doctor Foss regarding the percentage of stump cancers in relation to cancer of the cervix as a whole.

I prefer to utilize my time in presenting a brief summary of what I consider to be the most valuable recent contribution to discovery of unsuspected cancer of the cervix. Dr. R. W. Telinde, in collaboration with Dr. G. A. Galvin, recently published the surprising results of a most important study. In the clinic, a routine biopsy was taken

[1] Foss, Harold L., and Babcock, J. Reed: Total Abdominal Hysterectomy. Surg., Gynec. and Obst., **76**, 214–227, February, 1943.

from the cervix of every patient in the operating room and from many in the Out-Patient Department, to see in what percentage of cases there could be found early, but definite, malignant changes, and within a period of less than two years they have discovered in 16 cases the early histologic changes in the epithelium which have been recognized for some years by certain competent pathologists as incipient cancer. These changes are perfectly characteristic and are easily recognized by anyone familiar with the histology of this area. In these 16 cases in which these early preinvasive changes took place in the epithelium, the uterus was totally removed in all, and in 15 of them, later in the laboratory, they were able by studying multiple sections to demonstrate definite invasion by carcinoma.

Furthermore, in a series of 300 cases in which total hysterectomy had been performed for benign disease, in which carcinoma was not suspected, four cases of unmistakable carcinoma were found. We are going to hear a great deal about this work I am sure, because it will undoubtedly be quoted as the final and convincing argument in favor of routine total hysterectomy. But I cannot subscribe to this view, because in all of these 16 cases the cervices were diseased; they had chronic cervicitis or chronic discharge or slight bleeding. I have no quarrel with those advocating routine total hysterectomy in these cases, because I do it myself.

In my private practice, over a period of 34 years, I have seen only one case of carcinoma of the stump of the cervix subsequent to subtotal hysterectomy.

I am familiar with Doctor Foss' operation, which is somewhat similar to the operation I published in 1929, devised to meet the three main causes of trouble in performing total hysterectomy; namely, hemorrhage during operation and postoperatively, postoperative peritonitis, and damage done to the bladder or ureters resulting in later fistulae. I spent 18 months developing this operation with the gratifying result that up to the present time, in a consecutive series of something more than 200 total abdominal hysterectomies for benign pathology, I have not had any troublesome hemorrhage during operation; no postoperative hemorrhage, no urinary tract fistulae and no postoperative peritonitis. I am, therefore, quite satisfied with this operation. I do not like the application of a clamp across the vault of the vagina nor the use of the cautery. I prefer rather to see the entire vaginal cuff open, so that I can ligate all bleeding vessels prior to its closure, and I am meticulously careful to cleanse the vagina and cervix as thoroughly as possible prior to the celiotomy, which I do myself, in addition to routine surgical toilet by an assistant.

In conclusion, permit me to say that I cannot endorse the teaching that total hysterectomy is as simple as subtotal, and that I do not believe any convincing evidence has been presented to justify the routine removal of a normal cervix when subtotal hysterectomy is indicated for benign disease of the corpus.

Dr. Emil Novak, Baltimore, Md.: I believe that Doctor Foss has given us a very fair appraisal of this problem which, as Doctor Richardson says, has long been a bone of contention among gynecologists. Almost *a priori*, I believe that everyone would concede that, if it could be done as safely as subtotal hysterectomy, the total removal of the uterus would be the operation of choice. The cervix serves no function after removal of the uterus, and just as good a pelvic floor can be given if it is removed. Its retention carries with it not only the possibility of later cancer but also of troublesome leukorrhea, even if such procedures as cervical cauterization are carried out. From time to time I have felt obliged to enucleate a cervix which had been left in perhaps years before, because of chronic infection and at times slight bleeding which caused concern as to the possibility of cancerous change.

On the other hand, to argue that total hysterectomy is always as simple and safe as the subtotal method appears to me to be rather absurd. While often it is, one should not forget that the removal of a cervix which may lie deep in the pelvis and be firmly fixed, carries one into a definitely dangerous zone so far as the ureter and bladder are concerned. Marked obesity, an unusually deep pelvis, extensive adhesions which fix the uterus and cervix almost immovably in the pelvis, extensive endometriosis which welds the uterus or cervix solidly to the rectum—these are some of the conditions which will influence me in a certain number of cases to choose the subtotal method. To insist on doing the total operation in all cases is just as bad surgery as never to do it.

Individualization is wise here as in every other surgical procedure. In spite of this, the total operation is done in the great majority, at least 75 per cent, of all my own hysterectomies. The more frequently one does the total operation, the easier one finds it to perform, and it is to be preferred unless some definite contraindication is encountered. By the same token, the occasional operator will probably be wise to select the subtotal method more often than the total. Were the latter attempted as a routine by relatively inexperienced men, it is certain that mortality and morbidity rates would both be increased.

To sum up, the chief factors on which the decision between total and subtotal hysterectomy in the individual case should be based are (1) a conscientious self-appraisal by the surgeon as to his own capabilities; (2) the technical problems presented by the individual case; and (3) the condition of the cervix.

Finally, I may say that I am familiar with the work alluded to by Doctor Richardson on very early phases of cancer. The latter, however, may be found in cervices which show little or no evidence of laceration, chronic cervicitis or erosion, lesions generally thought to predispose to cancer. This constitutes another good reason for total hysterectomy as the method of choice. As a matter of fact, many of the earliest cancers I have seen have been in cervices which showed little or no evidence of gross clinical change.

DR. CURTIS H. TYRONE, New Orleans, La.: The edited transcript was not received in time for publication. If it is received before the "Transactions of the Southern Surgical Association" is published, it will appear therein.

DR. HAROLD L. FOSS, Danville, Pa. (closing): Doctor Richardson's figures dealing with studies of the cervix are interesting and the findings reported parallel those that have been presented at numerous times by other investigators. Cervices permitted to remain following the removal of the body of the uterus may become carcinomatous in a certain percentage of cases but possibly in not over one or two. For this reason, if operative mortality, as I found it in studying the reports of many writers, is to be about 3 per cent for panhysterectomy, obviously, as Doctor Richardson states, it is bad teaching to advocate the operation as a *routine*, whether the lesion of the fundus is benign or malignant. However, this was strongly advocated recently in a paper coming from one of our leading medical schools.

A panhysterectomy in a stout individual may become one of the most difficult operations performed within the abdomen, yet in some institutions these procedures are routinely turned over to residents. In one large teaching institution, recently a mortality as low as 1.5 per cent was reported where routine panhysterectomies were carried out, many of the operations being performed by assistants. However, nothing was said with reference to morbidity. Prolonged hospital residence, with delayed healing, with vesicovaginal and ureterovaginal fistulae are not uncommon in this operation and yet the patient may recover.

Doctor Novak sums up completely my own conclusions as I have attempted to express them in the paper and that is, that panhysterectomy should be performed when indicated, probably in the majority of cases but, as Doctor Novak concludes, the operation should be performed only when it can be performed safely. I thoroughly agree with Doctor Tyrone that the term panhysterectomy is not a good one. It has crept into the nomenclature only to cause confusion. The terms "total" and "subtotal" are better English and are more accurate and descriptive.

SURGICAL PRINCIPLES UNDERLYING THE USE OF GRAFTS IN THE REPAIR OF PERIPHERAL NERVE INJURIES*

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WITHOUT QUESTION the most substantial contribution which was made to the surgery of peripheral nerve injuries from the material studied during World War I concerned diagnostic principles. The important work of Pollock, Coleman, Stookey, and others, established the criteria necessary to diagnose divided nerves by correct sensory and motor examinations and recovering lesions after repair. Those basic contributions which dealt with sensory overlap and supplementary movements of muscles have never been successfully challenged. In fact, other data added subsequently have corroborated their correctness and have only added diagnostic methods which demonstrate the same principles. In addition, the work of Huber, and his associates, during World War I established certain equally important experimental and microscopic facts concerning the degeneration and regeneration of nerve fibers.

Unfortunately, the results of surgical operations performed upon nerve injuries during the last war have been a total loss as a contribution to surgical progress in this field. Military records were incomplete and unsatisfactory to begin with, and then were lost within the bureaucracy of government, so that a study has never been possible. This, of course, is a great surgical tragedy because if there can ever be any justification for war it lies in the compilation of data from the enormous number of injuries, to the end that mankind may eventually be the beneficiary. It is this lack of surgical data concerning the results of various technics of nerve repair and types of suture material used during World War I which had led to the occupation of younger surgeons with technical matters almost to the exclusion of other lines of investigation in the present war.

There is an astonishing lack of agreement concerning the principles of the treatment of peripheral nerve injuries. There are some who teach that peripheral nerves will never regenerate even if the ends are sutured accurately together under the most favorable conditions, and there are some who believe that the ends of a divided nerve trunk will, in some mysterious and serpentine-like manner, seek each other out and of their own accord form a union. Then, there are some experimentalists, without practical surgical training, who have devised various types of collagen, arterial, venous, and metal cylinders into which the nerve ends are placed so that the downgrowing axis cylinders may be guided to a union with the distal segment. The hope, entertained by many surgeons, that a peripheral nerve injury will recover spontaneously has resulted in unjustifiable delays which have made

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successful repair impossible. Finally, it has never been sufficiently appreciated that the effector mechanisms, particularly the myoneural junctions in the muscles, are the most important factors in obtaining good functional results after nerve suture.

In September of 1942, it became necessary for the Senior Consultant in Neurologic Surgery to the European Theater of Operations to formulate a policy for the treatment of peripheral nerve injuries which would be simple, could not possibly be all inclusive, and would perhaps keep the young surgeons far forward in the combat zone from doing too little or too much.

There are certain simple, surgical principles which have been gathered from civilian and military experience and from the experimental laboratory which apply to the repair of injured nerves. The first, and most important, is that the ends of the nerve trunk should be brought into accurate apposition by an end-to-end suture at the earliest possible moment following division. This is the ideal situation which must be approached as closely as possible in the presence of the many factors which seriously interfere with its attainment.

The enormity of the soft tissue damage to an extremity may divert attention from the divided peripheral nerve just as a craniocerebral injury may cause one to overlook an injury elsewhere to the body. Cleansing of the wound with soap and water, careful surgical excision of the wound and realignment of a fracture of the bones must receive primary consideration, but they must be undertaken with the full realization that a missed opportunity to repair a divided nerve trunk early will result in a loss of function which nullifies the most accurately healed bony fragments. Therefore, if it is at all possible, the nerve ends should be apposed and united, with the finest silk and the smallest needles obtainable, by an accurate end-to-end suture which passes through the epineurium of the nerve and not through its substance. If the wound heals by primary intention, the best possible conditions for regeneration of the nerve have been established. If suppuration occurs, the nerve ends are in apposition and retraction with enormous bulbous or fusiform neuromas upon the separated ends will not make their resection, with a considerable loss of nerve trunk, necessary.

If there has been a loss of nerve substance so great that the nerve ends cannot be approximated, or if there is a bone or joint injury which does not allow the adjacent joint to be moved so that the ends can be approximated, or if it is surgically inadvisable to change the anatomic course of the nerve trunk, then it is incumbent upon the surgeon to identify the ends of the central and distal segments and introduce a metallic suture so that later secondary repair may be facilitated.

The question of whether or not a soft tissue injury can be closed after surgical cleansing and excision is sometimes not easily answered. This, then, raises the question of the value of the introduction of the sulfonamide drugs into the wound and their oral administration to control the course and virulence of the infection. The sulfonamides, or penicillin, do not and cannot

replace meticulous cleansing of the wound and surgical débridement. From experimental work which has been carried out in our laboratory upon gunshot injuries to nerve trunks in animals and from the examination and surgical treatment of extensive soft-tissue wounds with nerve injuries received in combat during the North African campaign by British and American soldiers, we believe that the sulfonamides properly used have a definite place in the treatment of such wounds and that they do not affect the regeneration and repair of the divided nerve.

It was recommended to the Chief Surgeon of the European Theater, that a sulfathiazole water-soluble jelly be made available to front line medical officers so that they might introduce it into the depths and crevices of an extensive soft-tissue extremity wound immediately upon its receipt. Following surgical cleansing and accurate débridement, the additional use of the sulfonamide powders or jellies will, in our opinion, make it possible to suture the divided nerve with greater safety from the effects of a suppurating wound. From our experience with extensive soft-tissue wounds with fractures of the long bones in which the nerve was not sutured at the time of the first definite surgical treatment, or was ignored, it became evident that such a healed wound, even though primarily infected, could be reopened, the nerve could be sutured and the wound closed without lighting up latent bacteria, within a much shorter interval of time, providing the sulfonamides were used locally in the wound at the time of the secondary operation and the sulfonamide blood level was adequate. This insurance was doubled if the sulfonamides had been used also at the time of injury and surgical débridement.

This free use of the sulfonamide drugs does not mean that we favor their use in every soft-tissue wound because we, also, believe that up to six hours, at least, after the receipt of a wound, it can be mechanically cleansed and surgically excised, the nerve sutured, the wound closed and primary union obtained. It does mean, however, that as a result of extensive experimental work we believe that although the local use of the sulfonamides may be followed by thin, silvery adhesions about the nerve trunk, and particularly at the line of suture, there is no definite demonstrable histologic evidence of interference with nerve axon regeneration.

As a matter of fact, there is reason to believe that the bugbear of the deleterious effects of infection upon the regeneration of nerve fibers is not as great as the habits of thought have led us to state. We have evidence to show that regenerating nerve fibers are not as vulnerable to infection as has been supposed. This is probably due to the inherent protective function of the perineurium against infection. We have seen histologic evidence of normal regenerating axons in the presence of suppuration which has affected the epineurium and the surrounding muscles or tendons. If, however, infection attacks the nerve fascicles; that is, if it exists within the perineurium, regenerating nerve fibers have never been seen to penetrate the area of leukocytic infiltration. Practically, then, this means that unless infection of

the exposed nerve fascicles in the severed ends of the nerve trunks exists, infection of the nerve bed or inflammation of the epineurium will not interfere with the down-growth of neuraxons into the distal segment.

We have also shown, for the first time, the damage which occurs to the nerve trunks, both above and below the site of injury, by the concussive effect of a gunshot wound even though the nerve trunk has not been anatomically interrupted. The myelin sheaths break down in a similar manner, but to a greater degree, than is seen following the sharp severance of a nerve. There is molecular decomposition of the myelin, with localized edema, a process best called necrobiotic, and entirely different from secondary, or wallerian, degeneration. This necrobiosis occurs under conditions which have one factor in common—the damage to the myelin sheaths in combination with apparent damage to the Schwann cells, with survival of the mesodermal endoneural elements. The damage to the Schwann cells seems to concern chiefly their proliferating decomposition activities. They are not destroyed in milder traumatic damage where axis cylinders are seen to survive the demyelinization. They enter into action in later nerve fiber regeneration and remyelinization, but fail to digest the myelin.

FIG. 1.—Sciatic nerve of cat 30 days following an end-to-end suture. The thin spider-like adhesions which follow the use of the sulfonamide powders introduced into the wound are illustrated.

Preceding nerve fiber regeneration, stimulation of the mesodermal cells by the non-fatty myelin decomposition products is very clearly seen and leads, wherever the traumatic lesion has reached a certain severity, to a confusion of the original endoneural structure and, by necessity, to a bewildering and irregular overproduction of regenerating nerve fibers. A heteromorphous nerve structure results. At a period when the neurotization is already well advanced, the myelin detritus can still be seen between the endoneural tubes and fibers.

Degrees of structural damage in such contused nerves may be found. The nerve with the slightest damage may show very little axis cylinder degeneration and for this reason only a relatively short transient disturbance of function; whereas, in a severe contusion even without any visible macroscopic nerve lesion, a complete wallerian degeneration of some or all nerve branches in combination with the heteromorphous type of endoneural proliferation and neurotization will be accompanied by a clinical picture similar to that produced by section of a nerve.

Nerve contusion may interrupt the continuity of the perineurium of nerve fascicles. This leads to a herniation of regenerating nerve fibers into the epineurium and the formation of traumatic neuromas. Again, the primary endoneural fibroblastic proliferation through the perineural gap results in the

sprouting of regenerating nerve fibers into the epineurium. These fibers are lost for the neurotization of the degenerating part of the nerve distal to the injury. These observations explain why some nerve contusions are followed by hardly any, or only limited, interruption of motor and sensory functions; whereas, in other cases contusion leads to complete paralysis and often only imperfect return of function.

A nerve trunk completely severed by a bullet differs greatly in its histologic aspects from a sharply sectioned nerve. The traumatic destruction is much more severe and extends centralward in the proximal segment not just a few millimeters but, very frequently, several centimeters. This same effect may be seen reaching just as far distally in the distal segment of the damaged

FIG. 2.—Photomicrograph of section of the distal segment of a nerve following end-to-end suture. Sulfadiazine was used locally in the wound. There is some thickening of the perineurium and subperineural edema. The latter is entirely inside the perineurium and does not penetrate between the regenerating nerve fibers. Regeneration was as good close to the edema as at a distance. (Bodian-fuchsin stain, ×85)

nerve. The effect on regeneration manifests itself in the heteromorphous type of organization and neurotization of the entire traumatized area.

The most difficult surgical problem, however, concerns the treatment of those nerve injuries in which there has been a loss of continuity in the nerve trunk so large as to preclude an end-to-end apposition under any circumstances. The use of various types of nerve grafts, the fixation of joints and the transplantation of tendons have been advocated in the treatment of these injuries, some of which are preventable if the correct surgical treatment is employed when the patient is first examined. There is resistance and opposition to the use of nerve grafts on the part of some surgeons who observed their use during the last War. It must be said, however, that grafts were

not used properly at that time, nor were the results of their use ever evaluated, so that this total opposition is unwarranted. As a matter of fact, the experimental work of Huber, and his associates, and our own recent animal investigations upon nerve grafts are of sufficient promise to make it mandatory that the problem be settled once and for all upon the many severe nerve injuries which are present in many Army general hospitals today.

Cable grafts, in which many strands of small nerves are used to unite the central and distal segments of a nerve trunk, we believe are doomed to failure because of the technical difficulties of suture, but also because regenerating nerve axons do not reach the distal segment over a trellis of small nerve trunks. The increased amount of epineurium and the scar tissue which develops between each nerve trunk constituting the cable greatly interfere with the regeneration of nerve fibers by increasing the mesodermal barriers in their pathway. Fixed grafts of any kind, regardless of the material or the method of fixation, are total experimental failures, and the 27 human cases in which Soviet surgeons have used such grafts are absolutely inconclusive clinically and histologically. The most favorable type of graft to use is either an autogenous or an homogenous nerve trunk of equal size to the divided nerve. Such autogenous grafts are impossible to obtain except in those instances, for example, in which all of the nerves to an upper extremity except the radial have been severed with a large loss of nerve trunk substance. Under such circumstances, it is entirely justifiable to sacrifice the ulnar nerve as an autogenous graft into the median in an attempt to regain sensory and motor function in the first finger and thumb. It is the homogenous type of graft which is most applicable, particularly in Army general hospitals which are amputation as well as neurosurgical centers.

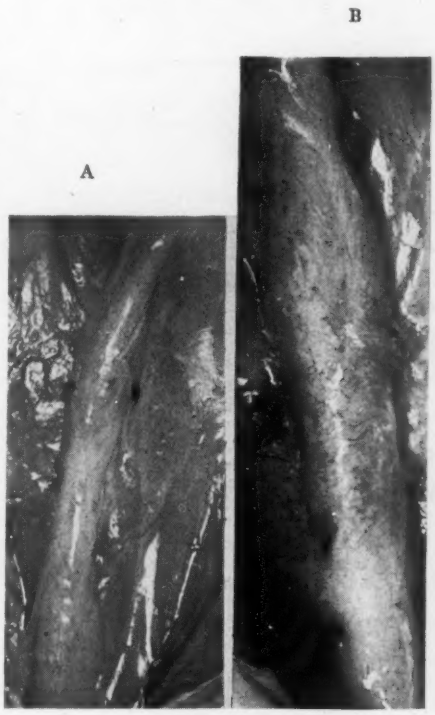

FIG. 3.—(A) An autogenous graft 60 days after implantation; (B) an homogenous graft 60 days after implantation.

The use of nerve graft banks is in a state of development. They involve elaborate preparations for freezing, drying, dehydrating and cold storage which must be made practical. From our experimental corroboration of Huber's work and from two patients operated upon in civilian practice, we believe that fresh homogenous grafts equal in size to the injured nerve should be used to repair large continuity defects in nerve trunks. Depending

upon the length of the graft, we believe that the distal suture line should be resected and resutured so that the down-growing axons in the graft can penetrate a less dense suture line into the distal segment. Animal experiments cannot provide complete proof of the practicability of this surgical step because the grafts used are not as long as those necessary in humans, but the evidence is in favor of such a procedure. It is quite possible that the dense

FIG. 4

FIG. 5

FIG. 4.—Photomicrograph of an autogenous graft 120 days after implantation showing an isomorphous structure and neurotization similar to that seen in a regenerating peripheral nerve. The old endoneurium is preserved and directs the band and nerve fiber proliferation. Remaining myelin decomposition products show an arrangement of original neurilemma tubes characteristic of a degenerating nerve. The borderline between perineurium and nerve fascicle is preserved. (Bodian-fuchsin stain, × 190)

FIG. 5.—Photomicrograph of an homogenous graft 52 days after transplantation showing an entirely heteromorphous structure and neurotization. Bundles of band fibers and regenerating nerve fibers pass between dense strands of proliferating collagenous fibers into the perineurium. (Bodian-fuchsin stain, × 190)

scar tissue which forms at the distal suture line in a long human nerve graft before the nerve fibers have been able to grow down that distance, prevents them from growing into the distal segment and may well explain the poor functional results thus far reported. Certainly the microscopic and clinical

FIG. 6

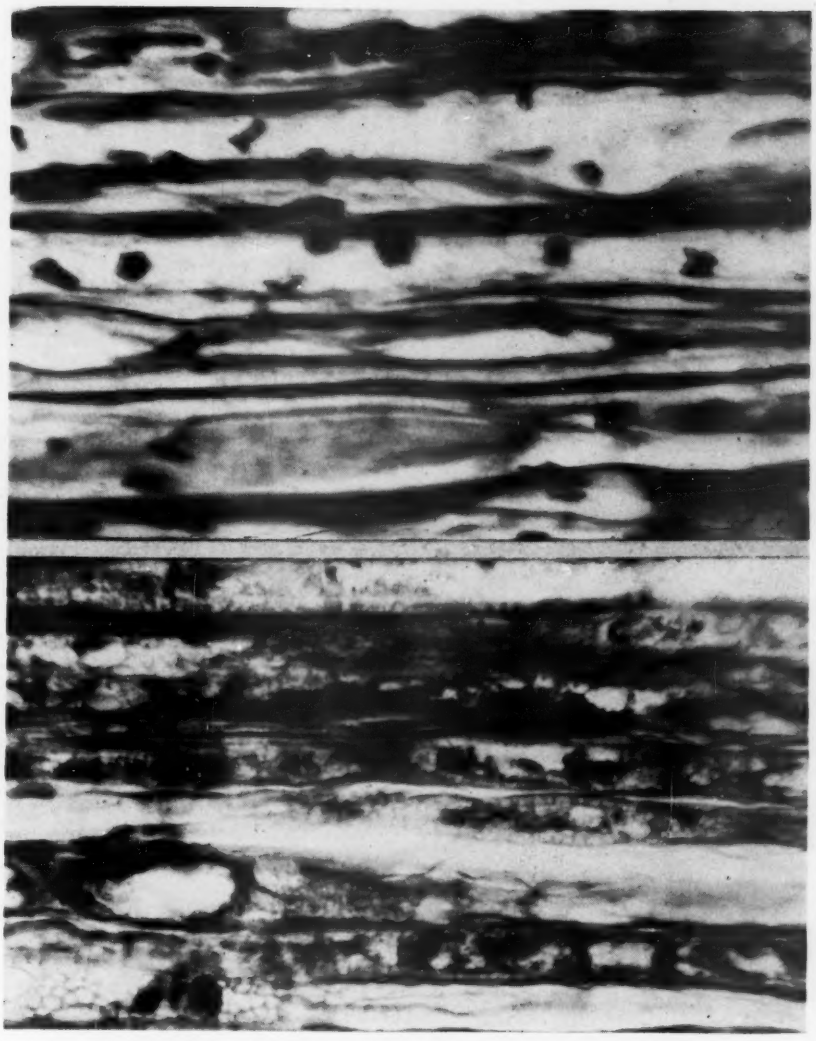

FIG. 7

FIG. 6.—Photomicrograph of the central segment of a nerve six days following a gunshot contusion. There is a destructive reaction of the axis cylinders some of which are swollen and disintegrated. There is a large amount of detritus and edema between the endoneural sheaths. One nerve fiber shows a well preserved axis cylinder surrounded by a swollen and partly vacuolated myelin sheath. In other portions myelin sheaths are more or less completely destroyed. General cellular proliferation of the endoneural cells and an accumulation of histiocytic elements within the detritus is seen. There is a beginning proliferation of Schwann cells. Nerve fiber regeneration is visible in the center. (Bodian-fuchsin stain, × 450)

FIG. 7.—Photomicrograph of distal segment of a nerve six days after gunshot contusion. The typical aspect of secondary degeneration is seen with the remainders of broken down axis cylinders, severely degenerated myelin sheaths with myelin globules, small and large vacuoles and beginning cellular reaction. Comparison with Figure 6 shows the difference between a traumatic and a secondary degeneration. (Bodian-fuchsin, × 450)

evidence of two cases from civilian life would support such a step. The use of autologous plasma suture methods to unite the central and distal segments of the nerve to the graft should receive careful clinical and experimental evaluation. Theoretically, the absence of any tension should make this suture technic an ideal choice.

FIG. 8.—Photomicrograph of an infected end-to-end nerve suture after 14 days. Regenerating nerve fibers may be seen crossing the suture line and following the path of outgrowing fibroblasts and collagenous fibers. There is an abscess on the periphery. (Bodian-fuchsin stain, × 390)

The distal suture line of a graft is always larger than the proximal suture line and it is larger in an homogenous graft than in an autogenous graft. It is the result of the endoneural and perineural mesodermal proliferation which unites the severed nerve ends to the graft. In our experiments, homogenous grafts, even more than autogenous grafts, always appeared thicker at the time of removal than at the time of transplantation. This increase in size is closely related to the amount of proliferated mesodermal tissue within and around the graft and also to the structure of the graft itself. More and denser adhesions are present around the homogenous grafts because there is also a more pronounced perineural and epineural mesodermal proliferation, but these adhesions carry blood vessels to the epineurium of the graft, the nerve segment and to the suture line. The viability of the graft is wholly dependent upon its vascularization from the surrounding tissues and, therefore, any structure placed around the graft such as a tantalum or

FIG. 9

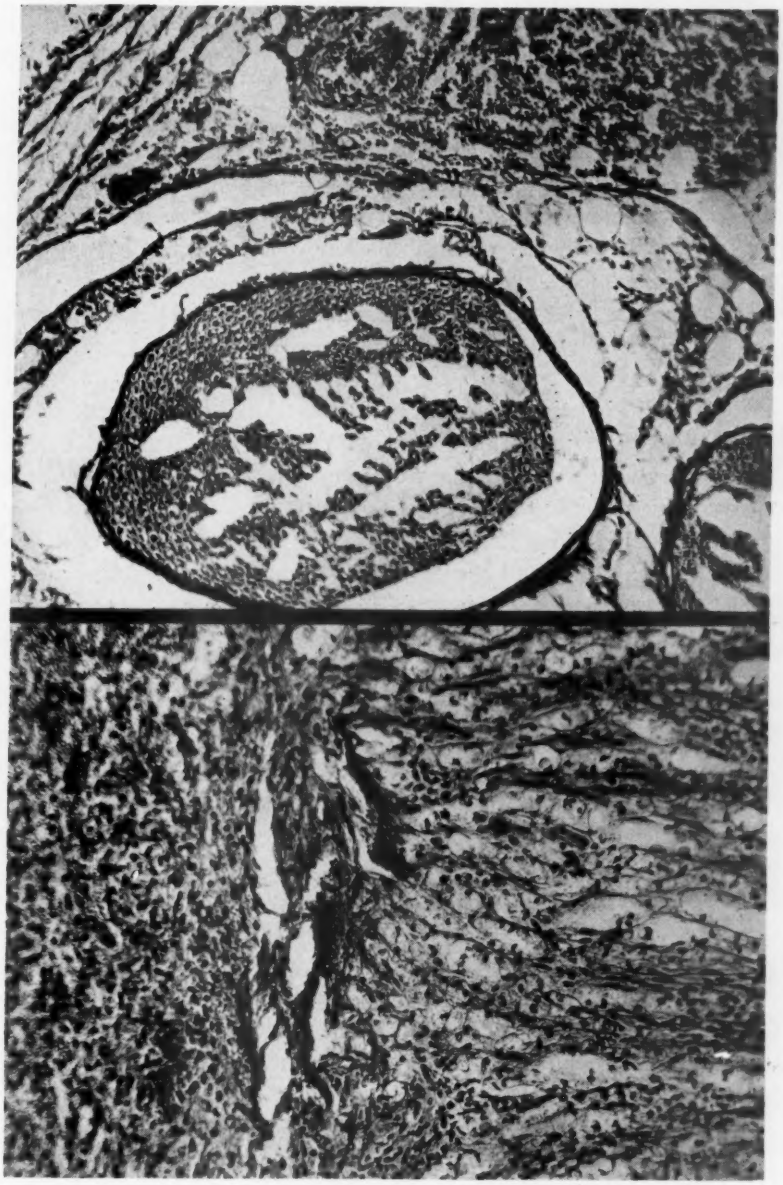

FIG. 10

FIG. 9.—Photomicrograph shows an abscess within the epineurium and an intact nerve fascicle surrounded by intact perineurium in no way disturbed by the surrounding abscess. (Bodian-fuchsin, × 125)

FIG. 10.—Photomicrograph of infected nerve suture showing degeneration with signs of trauma and beginning cell proliferation and inflammatory reaction. Connective tissue is seen growing at a right angle to the course of the nerve fibers. There is also proliferation of mesodermal tissue which seals off the endoneural tubes of the central segment, and which grows from the perineurium into the gap between the central and distal segments. (Bodian-fuchsin, × 185)

collagen cuff will prevent the growth of vessels into the graft and to that degree will interfere with the success of the transplant.

Regenerating nerve fibers, preceded by Schwann cells, follow the path of proliferating histiocytes, be it in the granulation tissue that fills the gap between the central and distal segments at the suture line, in the proliferating endoneural sheaths of the degenerating distal nerve segment, the degenerated or necrotic graft, or wherever histiocytic proliferation takes place. Autogenous grafts are characterized by a predominantly isomorphous structure; that is, one in which the original neurilemma structure is preserved. The majority of homogenous grafts show a heteromorphous structure, due to destruction of the original graft structure which follows the necrosis of the ectodermal and endoneural elements after transplantation. Neurotization of autogenous grafts is predominantly regular and parallel to the graft structure while in homogenous grafts the regenerating nerve fibers follow an irregular and deviating course. However, despite the large amount of regenerating nerve fibers lost in the epineurium of the suture lines and in the grafts of heteromorphous structure, the distal nerve segment often shows a satisfactory neurotization.

All operations for the repair of peripheral nerve injuries must be judged upon the basis of sound clinical examination for sensory and motor recovery, which appreciates the occurrence of overlap of sensation from adjacent uninjured nerves into the anatomic area of supply of the injured nerve and the development of supplementary muscle movements. In other words, recovery of function after nerve repair must be based upon the return of pin prick sensation in the isolated area of supply for pin prick of the injured nerve, and upon the patient's ability to perform muscular movements which are dependent upon muscles supplied only by the injured nerve. Strict adherence to these criteria will prevent reports of recovery of function after nerve repair which are either inaccurate or false.

Clinical and experimental observations warrant the statement that the operation of choice for the repair of an injured peripheral nerve in man, where direct end-to-end suture cannot be performed, is the transplantation of a nerve graft. The most satisfactory results can be expected from the use of a fresh autogenous graft of equal size to the injured nerve, but if this is impossible to realize, the use of a fresh homogenous nerve transplant is justified. Finally, careful clinical studies before and after operation should be made upon the patients in whom such grafts are employed so that their value in man can be fully determined.

DISCUSSION.—DR. JOHN STAIGE DAVIS, Baltimore, Md.: I would like to ask what is the greatest length of nerve graft Doctor Davis has been successful with.

LT. COL. MICHAEL E. DEBAKEY, Washington, D. C.: I want to comment on one aspect of the subject referred to by Doctor Davis, that is the wasted knowledge concerning methods of treatment of peripheral nerve injuries in the last war. Recognizing the importance of this problem, the Surgeon-General has established a peripheral nerve injury registry for the purpose of evaluating the relative efficacy of different methods

of therapy as promptly as possible. It is believed that this procedure will provide valuable information long needed on the subject of peripheral nerve injury repair.

DR. CLAUDE C. COLEMAN, Richmond, Va.: I do not know of anything to disagree with in Doctor Davis' paper. I should like to say that Doctor Davis is one of the few men who kept up his interest in surgery of peripheral nerves between World War I and the present conflict. The lessons learned from the vast material of World War I in plastic surgery and other types of war surgery were subsequently applied in civilian practice, but peripheral nerve surgery received very little attention in the literature for two decades following World War I. As a result, it seems to me that these injuries have been very badly handled in civilian life. For instance, I think most of us have seen ulnar and median nerves sutured to the tendons at the wrist joint. This so-called "minor" operation of suturing nerves, after what is a very serious injury, should require the services of an expert surgeon and should not be entrusted to those not familiar with nerve surgery.

I want to emphasize one thing, that is, that out of the vast material of World War I we got practically no information insofar as the results of surgery were concerned. I was very actively engaged in nerve surgery of World War I, and I know nothing of what finally happened to these patients with nerve injuries. Occasionally, I examined one of the patients in Richmond but, as a whole, this vast material was not carefully studied for end-results. In this war, I think we all hope that there will be established criteria of recovery for every individual nerve. If we do this, and the cases are followed for three, four or five years after operation, we will then have the information we should have had following the last war. I am glad to know that steps have been taken to bring about a competent follow-up in nerve injury cases. We are in a different position in this war. We entered the war with a large number of surgeons trained in nerve surgery and we ought to get the maximum benefit from this experience.

There are certain inherent obstacles to complete success in nerve surgery. Some of these obstacles have been removed since World War I through better surgery and chemotherapy. At that time operations frequently had to be postponed because of persisting infection. This delay permitted the development of crippling sequelae from denervation, such as periarticular fibrosis and marked muscle atrophy. By supplementing adequate surgical treatment with chemotherapy, divided nerves can be repaired early, and early suture of peripheral nerves is always desirable.

DR. JOSEPH E. J. KING, New York, N. Y.: First, I want to thank Doctor Davis for this splendid paper, and in the same breath I would like to get after Doctor Coleman for his very modest attitude about the work he did during World War I, and should like to say of Doctor Frazier, and his staff, that the records were splendid and the work was good. All the books and monographs I have seen on nerve surgery contain no better sensory diagrams than those made by Baird, Buerki, Kennedy, Anderson, and others. The records they kept after suture, both in our department and in the physical therapy department, were complete in detail. That they may be buried under much bureaucratic dust I will agree, but that they were good I will assert. These records should be reviewed together with those found later in the Veterans' Bureau in order to learn about the results obtained.

I have been told by Foerster, Coleman, Frazier, and others (and it is my own experience and that of younger men today) that the best results to be expected from peripheral nerve surgery are in cases of accurate approximation of the ends with the least degree of rotation possible, without tension, and with good approximation of the ends with a very fine suture, and if the nerve suture is not done under these circumstances, a rather poor result can be expected. I have never heard of a perfect result in suture of a divided nerve. I doubt seriously that, if you divided a nerve and immediately resutured it, you would have a perfect recovery. However, we should attempt to attain good, if not perfect, results.

We were at a tremendous disadvantage in the last war in having patients come late after injury. Transportation was slow, the infected cases were many, and it took considerable time to clean up the infection. Therefore, our sutures were accomplished much later. Nevertheless, some good results followed nerve suture, even under these circumstances. I was consultant to the Veterans' Bureau for 15 years after the war

and I saw a great many of these patients who had been operated upon by various men. Some of the results were pretty good, not perfect, but fairly good. I was able to follow up only five cases of nerve graft, and all I saw were failures. All were trellis-grafts placed in poor tissue—there was nothing else to be done—and all were failures. The subject of Doctor Davis' paper, the use of nerve transplants if they can be preserved and obtained from stock bottles, should offer some likelihood that good results may be obtained. But if trellis-grafts have to be used I think they will prove to be failures.

Dr. J. Albert Key, St. Louis, Mo.: I enjoyed this paper and am particularly interested that the fetish that the peripheral nerves are especially susceptible to infection has been quelled. It is my impression that they have stood up under infection very well. I think there is a marked tendency to put the bone lesion first, feeling that we must get the infection in the bone cleaned up before the nerve is sutured. This is a mistake. In some cases nerve suture should take precedence over the infection of bone. If the patient cannot use the hand it does not make much difference whether you get union or not.

I am glad to know that Doctor Davis has not thrown the sulfunamides out of the window. There is no question in my mind but that, if intelligently used, they will improve surgery. We cannot eliminate chronic infection in bone until we have excised it, but we can subdue it to a point where we can operate with impunity in the vicinity and avoid a late, usually futile nerve operation in dense scar tissue. Where you are going to transplant a nerve you can do the proximal suture first and let regeneration start, and suture the distal end of the graft to the distal end of the nerve at some later date.

Col. E. D. Churchill, Boston, Mass.: Surgeons in an overseas theater are acutely aware of the difficult problem in peripheral nerve reconstruction that are being returned to the United States. I can only assure you that we have not been complacent about the matter, and many conferences have been held in an attempt to find a solution. At the present time the policy relating to the surgical management of anatomic severance of a nerve is as follows: (1) The forward surgeon at the time of the initial débridement makes a careful record of the injury as he observes it. Preoperative appraisal of nerve injury is notoriously difficult and inexact in patients with multiple wounds, particularly if they are suffering from shock. The most precise information comes from anatomic observations at operation. Here again, it may not be desirable to embark upon a painstaking dissection with extension of the field of operation beyond the zone of devitalized tissues. (2) Dusting of the wound with sulfonamide may be omitted—certainly in the area of the nerve trunk. (3) Exposed nerves are covered with muscle so that the dry fine-mesh gauze used as a filler is not in contact with the nerve. Vaselined gauze is not recommended. (4) The joints above and below the point of injury are immobilized to minimize retraction of the nerve. (5) A firm pressure dressing supported by a plaster of paris shell is designed to reduce wound exudation. (6) Penicillin therapy is maintained by the systemic route. (7) On reaching a general hospital the original dressing is removed under aseptic precautions in the operating room. This usually is possible on or shortly after the fourth day after injury. The depths of the wound are revisioned and the nerve injury reassessed. Electrical tests may be made if desired. Oftentimes a more deliberate examination will correct or supplement the initial notes made in the forward area. Appraisal at this time is based on the ultimate functional restoration of the extremity, taking into consideration muscle damage and bone or joint lesions in relation to the nerve injury. Procedures such as muscle suture or even shortening of the limb by removal of devitalized comminuted bone fragments may be carried out at this time. The divided ends of the nerves may be approximated by a single fixation suture. The wound is closed if sepsis is not present, or if further excision of sequestrating tissue adequately prepares the wound for closure. Closure of the skin may be further staged, or if a large skin defect exists, a skin graft is applied at once or as a staged procedure. (8) When first intention healing has been secured—and this results in 80 to 95 per cent of cases—formal suture of the nerve is undertaken. This should be feasible in many cases during the third or fourth week after injury.

Throughout the course of reparative surgery, the patient is protected from the hazards of invasive infection by systemic penicillin therapy. We do not consider that the local usage of sulfonamides contributes to the success of the program and, until

further evidence of its efficacy is presented, choose to use penicillin by the intramuscular route rather than as a topical application.

During the staged operations of a program of reparative surgery, the red cell volume of the patient must be kept at normal levels by repeated whole blood transfusions.

DR. LOYAL DAVIS, Chicago, Ill. (closing): As stated in my paper, I have had the opportunity in civilian practice of performing three nerve grafts; one autogenous and two homogenous grafts. In answer to Doctor Davis' question, the longest graft we have used measures five inches, and has been in place for eight years. All these grafts remained viable, and the most successful has been the autogenous graft, which we would expect from our experiments.

I am aware of the Surgeon-General's attempts to have patients with peripheral nerve lesions followed for a long period after repair. As a matter of fact, this was suggested in a memo written as Senior Consultant in Neurological Surgery in the European Theater of Operations, and I am delighted to learn that it has been put into effect, as Doctor DeBakey has indicated. I think, however, it is necessary to go further and say that, when patients are discharged to the Veterans' Administration their compensation depends in part upon their willingness to return at designated intervals for examination by competent individuals.

As I have stated before, I had the opportunity of seeing soft-tissue wounds of the extremities complicated by peripheral nerve injuries among British and American soldiers in North Africa after they had been returned to England. All these wounds were weeks or months old and had not been closed primarily. The wounds had either suppurated or had been potentially infected; some had received sulfonamide at the time of injury some had not. The point I wish to make is that we were able to open those wounds, suture the nerve earlier, than we had ever dared in the past. Sulfonamides were used at the time the wounds were reopened and the wound sutured, but, inasmuch, as good surgical technic was also used it is not clear where the credit belongs. The point, again, is that nerve injuries must be sutured early because atrophy of muscles, fibrosis of joints and tendons will occur to such an extent that even a nerve sutured end-to-end will not be successful because the end-organs, that is, the effector mechanism, cannot function.

We forget that a nerve will regenerate under the most unfavorable conditions, so that it is not a problem of regeneration of fibers so much as it is a problem of re-enervation of the muscles to which the nerve grows. It is the end-organ which is important. Splinting and massage help to keep the effective mechanisms in good condition, but without union of the nerve ends functional results cannot be obtained.

It is illogical and completely unsurgical to recommend a delayed peripheral nerve suture. This does not mean that under the terrific conditions of battle one must suture a nerve in an unsuitable environment, or under unsurgical conditions. It means only that those cases should be evacuated as rapidly as possible to a hospital and to a surgeon who is capable and has the facilities available for performing nerve repair. Any policy which does not make use of this fundamental process of joining nerve ends together at the earliest possible moment is surgically unsound. Delay also increases the neuroma formation upon the cut ends of divided nerve and results in a loss of nerve continuity. This may make it impossible to obtain an end-to-end suture, by any surgical procedure, which is the ideal method of repair. It may then become necessary to use nerve grafts and joint operations, which cannot hope to produce results that approach the return of innervation to the muscles supplied by the divided nerve.

As I stated, we are not among those who believe that the sulfonamides or any other chemotherapeutic agent should be used in all wounds. They will not replace surgical treatment. We have shown, however, that, in our opinion, their use does not interfere with the regeneration of nerve fibers. The policy of suturing peripheral nerves as early as possible has been justified, I understand, from the large number which were sutured within a few days after injury following the invasion of Normandy. If the young medical officers far forward are not sufficiently well acquainted with proper methods of treating soft-tissue wounds accompanied by peripheral nerve injuries, that is all the more reason why there should be a Consultant in Neurosurgery who is mobile enough to see these men and give advice, and help them with their problems.

OBSERVATIONS ON THE CONVERSION OF NORMAL INTO MALIGNANT CELLS*†

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THIS COMMUNICATION is an abbreviated account of some work carried out in the Tissue Culture Laboratories in the Johns Hopkins Hospital and the Carnegie Institution. A full and carefully prepared report is in preparation and will be published by Gey and Gey.

During the source of experiments requiring the continuous culture of rat mesenchyme, some of the normal cells became permanently altered. The characteristics of the altered cells led the observers to suspect that the cells had undergone malignant transformation. This alteration has occurred on three occasions. In two of these three instances the actual transformation was not observed at its inception, but on the third instance some of the earliest stages in the transformation were observed and recorded photographically.

The original tissue from which the cultures were started was obtained from a normal adult rat of the Philadelphia Albino strain. This strain has a very low incidence of tumors. A bit of subcutaneous areolar tissue was used for the primary explantation. Not all of the strains derived from this tissue have become altered; in fact, the oldest unaltered substrain is now over six years old and continues to reproduce with unerring accuracy cells that are morphologically the same.

The first alteration that occurred was noticed four months after the explantation of the subcutaneous areolar tissue. This deviation from the normal was the occurrence of many cells dividing in an abnormal manner. Not only did one see many tripolar mitotic figures, but also occasional tetrapolar ones. Over a period of weeks the proportion of abnormally dividing cells to normal ones steadily increased. Later changes in the size and shape of the cells and variations in the rate of cell division were observed. These changes gave rise to the suspicion that the cells had become malignant. To test this hypothesis, young healthy rats were inoculated with altered cells, and a very cellular sarcoma developed at the sites of the inoculations. These tumors were transplanted into other rats and produced invasive neoplasms which occasionally metastasized. Tissue cultures derived from these tumors usually grew rapidly. The cells in culture bore some resemblance to, but were not identical with, the altered cells which were first inoculated. In addition to the tumor derived from the initial inoculation, a number of other tumors were obtained by the

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† Aided by a grant-in-aid from Sharp and Dohme.

periodic inoculation of subcultures of the altered cells. The cytologic appearance and behavior of these tumors differ widely from each other and from the original tumor.

The third instance of alteration of the rat fibroblasts occurred over two years after the explantation of the subcutaneous areolar tissue. This alteration when first seen in the living tissue culture consisted of the presence of rounded cells amid delicate sheets of fusiform fibroblasts. A liquefaction of the medium occurred whenever the rounded cells were present in large numbers. With prolonged cultivation the new cells increased rapidly in number, and abnormal mitoses were seen in these areas. A striking change took place in the nuclei of many cells. At first the newly altered cells showed nuclei that were slightly larger than those of the cells of origin. Later the nuclei became irregular in outline, very granular, and in stained preparations the altered nuclei were hyperchromatic. These changes, however, were not uniform, but in a single preparation one could see nuclei that varied greatly in form and size. Another evidence of alteration that became apparent was the change that occurred in the cohesion between the cells making up a colony. The normal fibroblasts produced colonies that showed rather marked cohesion, whereas the altered cells seemed to digest the surrounding medium and this resulted in loss of cohesion. Finally, the colonies of altered cells grew more rapidly than those of the parent strain. The changes just described were shown to be coincident with the development of malignant characteristics, for where colonies of altered and unaltered cells were inoculated into rats the former produced sarcomata at the site of inoculation, the latter never did so.

In every carefully planned experiment one always sets up adequate controls, but it is not possible to do so when the variables are still unknown. It is noteworthy, however, that some of the cells of the original explant have continued for six years to divide in an orderly manner and continue to produce cells that are morphologically and culturally identical with the original fibroblasts.

The possible explanations of the foregoing observations are several. Throughout the course of these experiments there were several strains of malignant cells being maintained in continuous culture in the laboratory. It might be conceivable that some of these malignant cells had contaminated the colonies of fibroblasts. That such contamination should occur three times with intervals of months, and always affect the subcultures of the same strain, is highly improbable. Furthermore, the appearance of the tumor cells of the altered strains is totally unlike any other cells seen in the laboratory. These differences in appearance were clearly brought out when mixed cultures of the existing malignant strains and the altered cells were prepared. Deliberate treatment of some of the normal rat fibroblasts with the cell-free filtrates of the culture medium maintaining other tumor strains growing in the laboratory did not evoke any permanent alteration in the fibroblasts.

It is well known that irradiation of normal tissue *in vivo* sometimes results in malignant transformation of the burned tissues. At the time of the occurrence of the first two alterations an experiment was being carried on in the laboratory to study the tolerance of certain cells to *gamma* irradiation. The radium was well shielded with lead, and the amount of stray radiation received by the cells was between 40 and 200 times the total natural earth radiation background. We know from other experiments in which several strains of normal rat fibroblasts were exposed continually to far greater doses of *gamma* rays that no permanent changes occurred. A stronger argument against the suggestion that stray *gamma* irradiation provoked the conversion of the normal into malignant ones is the fact that the third instance of this conversion took place several months after the experiment with radium terminated. Another agent capable of bringing about malignant changes in cells is one of the carcinogenic hydrocarbons such as methyl cholanthrene. During the occurrence of the alterations which form the subject of this communication there was no known contamination with any of the isolated carcinogenic compounds.

The medium in which the cells were grown was entirely heterologous except for a few passages at the time of the first explantation from the rat. In these few instances 10 per cent rat serum was added to the culture medium, but at all times thereafter the medium had the following composition: 10 per cent balanced salt solution, 10 per cent bovine embryo extract, 40 per cent human placental cord serum, and 40 per cent chicken plasma. It is true that such a medium is exceedingly rich in growth-stimulating hormones, but other strains of cells have been maintained in continual contact with media of this composition for over ten years and have not shown the transformation recorded in this paper.

Finally, a causative agent that might be suspected is the chance occurrence of a virus-like body. To test this hypothesis cell-free filtrates of the culture medium in which the alteration was occurring were added to the medium in which normal fibroblasts of the parent strain were growing but no mutation resulted. Similarly, cell-free filtrates of medium in which tumor cells had grown were used with negative results. These experiments, however, do not preclude the presence of a virus-like substance for it is possible that such an agent after entering or developing within a single cell might remain intracellular and be passed on to succeeding generations of cells at the time of division. Experiments are now in progress which were designed to test this possibility.

Among the many interesting speculations evoked by the observations recorded in this paper is one which we have attempted to study. The question arises what effect, if any, does a malignant cell have upon adjacent benign cells. A method has been devised by Doctor Gey for the isolation, without serious trauma, of a single malignant cell. Such cells have been transferred to culture media alongside normal fibroblasts. The division and subsequent multiplication of the malignant cell has been photographically recorded, and a tumor strain has been derived from such a single cell. In

the preliminary experiments, however, there was no discernible effect upon the fibroblasts.

SUMMARY

A brief account is given of the transformation of seemingly normal rat fibroblasts into several strains of malignant cells. These conversions are permanent and are characterized by changes:

1. In the morphology of the cells;
2. In the pattern of cellular division;
3. In cultural characteristics of the colonies.

That these changes were evidences of the fibroblasts having become malignant was shown by the inoculation of altered cells into rats and the subsequent production of several different types of malignant tumors. Some possible explanations for the occurrence of these changes are considered, but the actual demonstration of a single causative factor is lacking.

DISCUSSION.—DR. J. SHELTON HORSLEY, Richmond, Va.: This paper and demonstration is very interesting and thrilling. The cause of cancer with the changes between benign and malignant cells is a problem that has been studied in many laboratories. According to Ewing, the occurrence of cancer involves two factors: One is what he termed the *causal* genesis of cancer and has to do with the inciting factors leading to the development of malignancy. The other is the *formal* genesis which has to do with the factors responsible for the cancer cell and its unlimited capacity for growth. Many agents are involved in the causal genesis of cancer, but they may be considered as only starting a series of tissue changes or conditions which tend to turn into malignancy.

There are, of course, many things that seem to constitute either the causal genesis or the formal genesis for the conversion of normal cells into cancer cells. Aside from the carcinogenic chemicals and irradiation, estrogenic products and the milk factor are particularly interesting. It has been known for some years that in mice and even in rats cancer of the breast could be produced by giving excessive amounts of estrin products, and though this has not been definitely proved in humans, there are reported cases which strongly suggest that this sometimes happens in women.

In the milk factor which has been demonstrated quite clearly in mice, a newborn litter of mice from a high mammary cancer strain if nursed by a foster mother of low mammary cancer strain immediately after birth will develop cancer of the breast infrequently, following the attributes of the foster mother. Whereas, if a litter of mice from a low cancer strain is taken immediately after birth to a foster mother of high cancer strain, this litter will develop cancer of the breast in a high percentage of cases, behaving just as would a litter of the high cancer strain if nursed by the natural mother. Just what is the mechanism of this has not been definitely determined. It may be that all carcinogenic factors, as in the very beautiful culture experiments shown by Doctor Firor, tend to remove the inhibitory properties of the normal cells.

An observation of C. C. Little which appeared in the Journal of the A. M. A. of May 13, 1944, is an intriguing speculation. According to Little, the carcinogenic influences are not dependent upon stimulation of normal cells to new growth, but upon removal of inhibitory influences. The normal cell is kept in its place by some influences that control it, but the carcinogenic influence removes these inhibitions and the cell then reverts to its original primeval type, somewhat like the amoeba, and grows without any restraints. In other words, the carcinogenic agents act by removing the restraints acquired during the process of evolution and civilization of the cells, and they then ran wild as they would without these inhibitions—this constitutes malignancy.

DR. ALFRED BLALOCK, Baltimore, Md.: Doctor Firor with his usual modesty claims very little credit for this work. Without attempting to discuss the interesting findings which have been related, I would simply like to say that Doctor Firor is in charge of the Division of Cellular Pathology in the Department of Surgery at Hopkins, and the staff, as well as the medical students, receive a great deal of benefit from following the important and fundamental work which is being performed.

MUCOID DISEASE OF THE APPENDIX*

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AS THE VESTIGIAL REMAINS of an ancestral colon and of similar structure the vermiform appendix, with the notable exception of primary malignancy, is subject to the common diseases of the colon. The nature and the course of disease, however, are affected by the size, shape and position of the appendix, by the blood supply which is terminal, and by stasis which is a natural state. Chronic obstruction of the lumen with retention of its contents produces morbid changes in the anatomy and in the physiology of the appendix which, with their complications, are known as mucoid disease. Because of its chronicity and comparative rarity this condition has not received the attention that it merits.

In the stomach mucus is a protective mechanism, in the colon it is an agent for the lubrication of feces that become solid from loss of water by absorption. In both the colon and the appendix mucus is secreted by columnar cells lining simple tubular glands in the mucosa. Spastic colon,[18] so-called mucous colitis, is a disease caused by a disturbance of the vegetative or autonomic nervous system that is marked by hypersecretion of mucus and by the passage of mucous casts of the colon. In it there are no symptoms referable to the appendix and it has no etiologic relationship to mucoid disease, although both the appendix and the colon are under autonomic nerve influence.

Chronic obliterative fibrosis from long-continued low grade inflammation converts the appendix throughout its length into a fibrous cord with loss of gland and of muscle structure. Chronic localized obstruction from stenosis, however, if of sufficient degree, is followed by cystic distention of the distal lumen. For distention to occur, secretion into the lumen must exceed fluid loss from it by drainage and by absorption. If enlargement is slow the resulting mucocele or hydrops may ultimately approach the size of the gravid uterus at full term.[8, 9, 12, 21] Rapid growth precipitates rupture. Fortunately, under modern conditions, most cases of chronic obstruction are operated upon as appendicitis before cystic change has become apparent. Increasing intraluminal pressure causes thinning of the appendiceal wall with the formation of diverticula. Diverticula occurring in the antemesenteric portion of the wall tend to rupture early; those developing into the meso-appendix grow more slowly and may themselves become secondary mucoceles. Bailey,[17] before this Association, has reported a case of a massive mucoid cyst of the meso-appendix, missed at appendicectomy, being removed at subsequent operation. Mucoceles produce indefinite symptoms and preoperative diagnosis is difficult.

Atrophy of the glands from intraluminal pressure may result in reduction of secretion into a mucocele. Growth stops when fluid loss by absorption

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balances fluid gain from secretion. Continued secretion into a mucocele with loss of fluid content by absorption results in the deposit of mineral salts as granules on the mucosa (Case 2) or as calculi (Case 4) in the lumen.

FIG. 1.—Photograph of the appendix opened. Giant faceted calculus of the appendix.

Ogilvie[7] has reported a case of cyst of the appendix, two and one-half by one and one-half inches in size, with calcification of the walls, in a railroad brakeman who complained of something solid "tapping him on the inside while he followed his daily work." Calculi may be multiple but as a rule are single. They vary in size; the largest reported[14] was in a man aged 61, which weighed 13.5 Gm. It consisted mainly of calcium and magnesium phosphates. Mucoceles rarely occur before middle age. We have seen, by invitation, a boy, age four, with a hard mass in the lower right abdomen which was shown roentgenographically to be a stone.[13] The preoperative diagnosis was verified at celiotomy. The stone, weighing 33 Grains, was contained in a mucocele that had recently perforated.

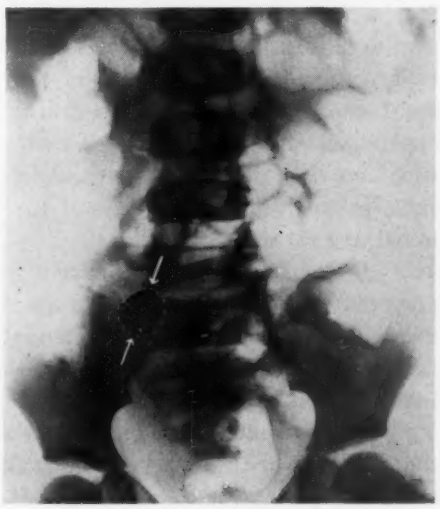

FIG. 2.—Roentgenogram of pelvis of four-year-old boy showing stone in mucocele of the appendix. Case of Dr. Adcock.

The viscid contents of a mucocele, like the white bile of a cholecystic hydrops or the clear fluid of a gonorrheal hydrosalpinx is practically sterile, and septic peritonitis does not follow rupture of a mucocele as its does perforation in acute appendicitis. The opaque material that escapes from a mucocele is not absorbed from the peritoneal cavity but blocks the lymphatics and remains as a foreign body to accumulate and produce ascites or "jelly-

belly," a bizarre disease that is termed pseudomyxoma peritonei. Due to chronic obstruction and inflammation the secretion into a mucocele becomes changed from mucin to pseudomucin by metaplasia rather than by degeneration of the goblet cells. The great increase in the volume of pseudomucin that accumulates in the abdomen after perforation of a mucocele makes it certain that, although transplants may not occur, secreting cells do escape from the appendix to live and to function in the peritoneal cavity. It is not logical to assume that the foreign body serositis which follows perforation activates the endothelial cells of the peritoneum to secrete pseudomucin.

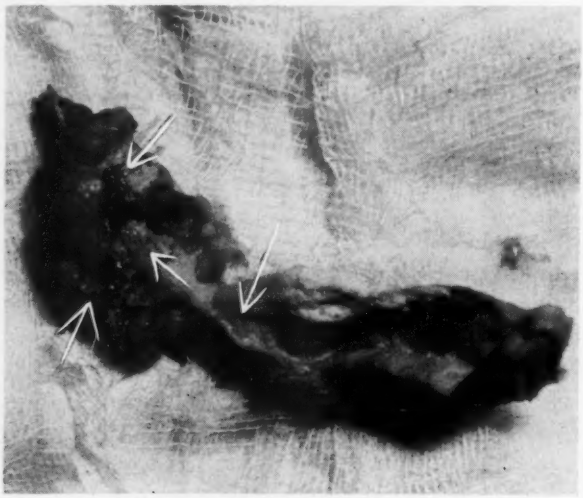

FIG. 3.—Photograph of mucocele of the appendix opened, showing deposit of mineral salts on mucosa. Case 2.

Largely because most cases of pseudomyxoma peritonei develop from rupture of adenomatous cysts of the ovary rather than from the appendix the disease is more common in women. It is not known why mucocele of the appendix is found as an associated lesion in a high percentage of women who have developed pseudomyxoma peritonei from ovarian cystadenoma. In some cases the cystadenoma and the mucocele have both ruptured and are found at operation to be discharging pseudomucin into the peritoneal cavity (Cases 3 and 4). Cystadenoma of the ovary is often malignant. Pseudomyxoma developing after the rupture of such a malignant cyst, although the cells are not invasive, is potentially carcinomatosis, which terminates in death. Metastases from pseudomyxoma peritonei of ovarian origin have been found in the chest.[11]

Woodruff and McDonald,[15] reviewing 43,000 appendices removed at the Mayo Clinic, found dilatation in 146 cases, an incidence of 0.3 per cent. In ten of the appendices they found adenocarcinoma, and in four of the ten cases there was an associated malignancy of the ovary. They believe that fatal cases of pseudomyxoma peritonei which develop after rupture of

mucoceles all originate in carcinomatous cystadenomas of the appendix. Although they do not state that any of the 146 cases of mucocele ruptured and developed fatal pseudomyxoma peritonei, their findings strongly suggest that peritoneal pseudomyxoma of *appendiceal as well as of ovarian origin* may be benign or malignant in type, depending upon the tissue from which it springs Possibly cells originating in a benign lesion may assume malignant characteristics after they reach the peritoneum. Primary cancer of the appendix is rare, of low grade malignancy, and requires microscopic identification. Norment[1] estimates that the relation of carcinoma of the appendix to carcinoma of other parts of the intestinal tract is as 1 to 250. I have never seen a case recognized by the surgeon at operation. Boyd[20] says true primary carcinoma of the appendix very rarely occurs. The condition commonly called primary carcinoma is really carcinoid tumor. It resembles carcinoma microscopically but is a benign lesion and is without symptoms.

Adenocarcinoma of the ovary is of frequent incidence and of high malignancy. Pseudomyxoma peritonei of appendiceal origin has a lower mortality rate. However, death in pseudomyxoma from either source may be mechanical and independent of cell structure, for it is most often due to intestinal obstruction. From serositis, pseudomucin in the free peritoneal cavity becomes enveloped into cystic masses of mucoid material which adhere to each other and to the viscera. Segments of small intestine may be bound in a colloid cast of the abdomen. Either condition results in chronic intestinal obstruction of varying degree. In late cases, that are operated upon after the intestine has become fixed, surgical treatment is futile.

Pseudomyxoma peritonei of appendiceal origin is a rare disease, less than 100 cases having been reported. The symptoms are those of a progressive, painless ascites which, untreated, results in death from intestinal obstruction. According to Seelig[3] the disease may run a benign or a malignant course clinically without furnishing any differentiating criteria, macroscopically or microscopically.

Mucoceles of the appendix should be removed before rupture occurs and pseudomyxoma peritonei develops. After rupture, if the mucocele, with all the pseudomucin that has escaped, is removed, the prognosis, in our experience, is good. Late cases, in which pseudomucin has become encysted and cannot be removed, tend to become obstructive. Drainage should not be employed. Cases that were drained by Ries[5] to allow the escape of masses which could not be completely removed at operation all died. All cases should be reported in order that authoritative factual information may be obtained. At operation upon females there are often associated adenomatous cysts of the ovary which should be removed. In cases originating in carcinomatous lesions of either the appendix or the ovary, maximum dosage of deep roentgenotherapy should be administered postoperatively.

CASE REPORTS

Case 1.—G. P. W., male, age 75, was seen July 2, 1937, with large bilateral inguinal herniae of long duration. At the repair of the right hernia, which was

strangulated, a perforated mucocele of the appendix, the size of an adult thumb, was removed with 500 cc. of brilliant amber jelly that was found free in the hernial sac and in the pelvis. Closure was without drainage. Radiation was not administered. On September 25, 1937, three months after dismissal, he returned for operation upon the left hernia, which had become strangulated. At this time the peritoneum was grossly normal and without pseudomucin or evidence of pseudomyxoma. He is reported to have died early in 1938 of hypertension.

Case 2.—Mrs. W. R., age 58, giving the history of having had gallbladder trouble for 20 years, was seen April 11, 1941, suffering from acute cholecystitis, with stones. At operation, the gallbladder containing pus and faceted stones was removed. The uterus and the ovaries were atrophic. A mucocele at the distal end of the appendix had ruptured, and about 750 cc. of yellow colloid material was found free in the peritoneal cavity. This, with the appendix, was removed. The surface of the mucosa of the mucocele was rough and granular like sandpaper from the deposit on it of mineral salts. The gallbladder region was drained. Recovery was without complication. No radiation therapy was administered. After three and one-half years she is in good health.

Case 3.—Mrs. W. M. S., age 61, has known she had had a slowly enlarging pelvic tumor for several years. She was suffering with abdominal pain of one week's duration. On examination, March 3, 1943, a cystic mass was found filling the pelvis and extending above the umbilicus. At operation, this proved to be a multilocular gelatinous cyst of the left ovary. Much yellow mucoid material from a ruptured loculus of it was free in the peritoneal cavity. There was a large mucocele of the appendix with a small rupture through which jelly, similar to that coming from the ovary, was being discharged into the abdomen. After the peritoneum had been freed of pseudomucin, the left ovary, the appendix and the gallbladder, with stones, were removed. The wound was closed without drainage. The patient did not receive deep roentgenotherapy, and after 20 months is in good health. *Pathologic Diagnoses* (Dr. Kenneth Lynch): Mucous cyst adenoma of the ovary. Mucocele of the appendix. Pseudomyxoma peritonei. Cholecystitis, chronic, with cholelithiasis.

Case 4.—Mrs. J. O., age 79, was admitted, March 3, 1944, complaining of difficulty in breathing and of progressive abdominal enlargement which began one year ago. Blood pressure and laboratory findings were normal. At operation, seven and one-half liters of thick yellow jelly were removed from the peritoneal cavity, much of it being contained in a massive papillomatous cyst of the right ovary that had ruptured. It was impossible to remove masses of jelly that were encysted in the great omentum and between coils of intestine. The left adnexa and the uterus were atrophic. There was a mucocele of the appendix with a small perforation at the tip. The appendix and the right adnexa were removed. *Pathologic Findings:* Cystic adenocarcinoma of the right ovary with rupture. Ruptured mucocele of the appendix which contained a small calculus. Pseudomyxoma peritonei.

Convalescence was uneventful. Deep roentgenotherapy was administered. On examination, September 25, 1944, her condition was good, with no evidence of ascites.

COMMENT

We have reported two cases of pseudomyxoma peritonei of appendiceal origin, one in a man, age 75 (Case 1), the other in a woman, age 58 (Case 2). In both the condition was symptomless and was found incidentally at operation, in one for strangulated hernia and in the other for cholecystitis with stones. No pseudomucin was found in the abdomen of the man at a second operation performed three months subsequent to the first. We also report two cases (Cases 3 and 4) of pseudomyxoma peritonei in women, age 61 and 79, respectively, in both of whom there were muoceles of the appendix with small perforations. In both, the disease had apparently originated in

cysts of the ovary that had ruptured in one (Case 3), a benign cystadenoma; in the other (Case 4), an adenocarcinoma. In Case 4 the fact that the mucocele of the appendix complicating adenocarcinoma of the ovary was itself without gross or microscopic evidence of malignancy, proves that malignancy was not a factor in its development. In Case 2 there was a deposit of mineral salts on the mucosa, and in Case 4 there was a small calculus in the mucocele—so that all phases of mucoid disease of the appendix except the late obstructive stages of pseudomyxoma peritonei have been illustrated in the four cases. All the patients have been white.

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APPENDICITIS: THE POSSIBLE EFFECTS OF SULFONAMIDES ON MORTALITY*

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THIS REPORT constitutes a survey of 1151 consecutive patients with acute appendicitis who were operated upon at the Baltimore City Hospitals over a period extending from January, 1935, to May 1, 1944. Six hundred and fifty-one of these were operated upon prior to June 19, 1940, with a resulting mortality rate of 5.2 per cent, and 500 were operated upon since June 19, 1940, with a resulting mortality rate of 1.2 per cent.

In the beginning, it should be emphasized that chemotherapy is not offered as a substitute for the fundamental rules that long have been practiced and recognized as most essential in the treatment of this disease. Early diagnosis and operation before the peritoneum has been materially soiled and careful handling of the intra- and extraperitoneal structures during operation are still most important factors in the control of this disease. It is also necessary to stress the fact that sulfanilamide is not administered either locally or systemically in those cases where the peritoneal cavity does not contain free pus, unless there develops some pulmonary or other complication. The available data on this subject, as well as the remarks made here, do not prove conclusively the value of the sulfonamides in this disease, whether they are used topically or otherwise.

It has been the practice in this clinic for many years, with few exceptions, to subject all patients suffering from acute appendicitis to an immediate operation. It is realized, of course, that the application of this rule in patients with far-advanced diffuse peritonitis is questionable. Many competent surgeons are of the opinion that a period of conservative treatment should be instituted before operation where such a condition exists. It is not the purpose of this paper to discuss the advisability or inadvisability of this rule. It is felt, however, that in a municipal hospital where a house officer staff is maintained with a chief resident who has had an experience of only five or more years of graduate hospital service, and where many of these patients are treated by the house staff in conjunction with members of a visiting staff, it is necessary to adopt a rather dogmatic policy with regard to the handling of routine patients. Therefore, more or less definite rules are followed in the treatment of various diseases and the disease under discussion is no exception. This does not mean that these rules are hidebound and that exceptions may not be made, but, in the main, the following rules apply:

(1) All patients whose symptoms present the picture of acute appendicitis

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are subjected to an early operation. If necessary, supportive treatment is instituted prior to or during the operative procedure. (2) A McBurney incision is made in almost every instance where the preoperative diagnosis of acute appendicitis seems reasonably certain. Right rectus and midline incisions are made infrequently. (3) Black silk is used throughout in most instances of simple acute appendicitis. However, catgut is employed in potentially infected cases. Plain 0 or 00 chromic catgut is used for appendiceal ties, and inversion of the stump is always carried out where the procedure is technically possible. The purse-string usually consists of double A oiled silk suture. (4) In patients with appendiceal abscess the appendix always is removed if it is readily accessible or if it can possibly be removed without breaking down the limiting abscess wall. (5) In more recent years sulfonamides have been used in the contaminated peritoneal cavity and systemic doses of the drug are given later. Prior to June, 1940, no sulfonamides were used consistently either in the peritoneal cavity or by oral methods.

In this review it is desired to point out the use and possible effect of the sulfonamide drugs on the mortality and, to a lesser extent, the morbidity rate. To suit the purpose of this discussion the usual pathologic classification, namely acute catarrhal, acute suppurative, acute perforative, and acute gangrenous appendicitis is being omitted. Instead the following classification is being made: simple acute, early perforative, appendiceal abscess, and perforation with diffuse peritonitis.

Outside of two anesthetic deaths which occurred on July 17, 1941, and October 5, 1941, respectively, there have been four deaths from acute appendicitis since June, 1940. This covers a period of almost four years, and gives a mortality rate, excluding the two anesthetic deaths, of 0.8 per cent against an over-all mortality rate of 1.2 per cent.

In this series of patients operated upon since July 19, 1940, and repeating again that the two anesthetic deaths referred to have been excluded, there were 27 patients with acute appendicitis and abscess formation, with one death. This is equivalent to a mortality rate of approximately 3.7 per cent.

There were 26 patients with acute appendicitis and early perforation and, again disregarding the one anesthetic death that occurred in this group, there were no deaths. There were 418 cases of simple acute appendicitis in which no sulfonamide drugs were used and there were no deaths. In addition, there were 29 patients with perforation and diffuse peritonitis, with three deaths. This gives a mortality rate in the latter group of approximately 10.4 per cent. The foregoing groups total 500 patients operated upon for acute appendicitis and, excluding two anesthetic deaths, gives a mortality rate of 0.8 per cent.

Prior to June 19, 1940, there were 56 patients treated for acute appendicitis who had early perforation. From this group there was one death, giving a mortality rate of approximately 1.8 per cent. There were 31 patients with abscess formation, and in this group there were three deaths, the mortality rate being 9.7 per cent. In addition, there were 87 cases diagnosed as acute

TABLE I

SUMMARY OF ALL DEATHS OCCURRING IN 1151 CASES OPERATED UPON FOR ACUTE APPENDICITIS

Case	No.	Race	Sex	Age	Hosp. Days	Date of Death	Classification of Disease: Simple Acute	Early Perf.	Perf. with Diff. Perito-nitis	Appen. Abscess	Sulfonamide Therapy	Drains	Anesthesia	Surgical Path.	Remarks
(1)	8179	W	M	35	1	7–17–35			1		No	Perito.	Sp. N. & G.	Gang.	
(2)	9862	C	F	29	4	10–18–35			1		No		Sp. N.	Gang.	Anesthetic death. Patient died before incision was made. Six-mo. pregnancy. Autopsy showed perforation with diffuse peritonitis.
(3)	10026	W	F	65	2	10–22–35			1		No	Fascia	Sp. Pont.	Acute	Paralytic ileus. Bronchopneumonia.
(4)	10508	W	F	22	7	11–21–35			1		No	Perito.	Sp. Nov.	Acute	Postoperative ileus. Patient was pregnant.
(5)	11229	C	M	50	5	12–23–35			1		No	Perito.	Sp. Nov.	Perf.	
(6)	12854	W	F	58	4	3–9–36			1		No	Fascia	Sp. Nov.	Acute	
(7)	14349	C	F	40	1	5–27–36			1		No	Perito.	Sp. Nov.	Acute	
(8)	14426	W	M	5	1	5–31–36			1		No	Perito.	Gen.	No rep.	
(9)	14501	C	F	40	1	6–4–36			1		No	Perito.	Sp. Nov.	Gang.	
(10)	14869	W	F	6	1	6–25–36			1		No	Perito.	Gen.	Acute	
(11)	15070	W	F	41	8	7–20–36			1		No	To peri-toneum	Sp. Nov.		Appendix not removed. Right tube and ovary gangrenous—removed. Delivered full term child 48 hours before surgery. Postoperative ileus and peritonitis.
(12)	16665	W	M	64	2	8–27–36			1		No	Perito.	Sp. Nov.	Acute	Autopsy showed localized peritonitis, atelectasis; stump intact.
(13)	15673	W	M	57	12	9–28–36				1	No	Perito.	Sp. Nov.	Acute	Appendix was removed. Postoperative peritonitis and cellulitis of abdominal wall. Autopsy showed perforation of cecum.
(14)	15441	W	F	32	10	11–30–36	1		1		No	No	Sp. Nov.	No rep.	Far advanced bilateral pulmonary tuberculosis.
(15)	20816	W	M	62	4	2–7–37			1		No	Perito.	Gen.	Acute	Hemiplegia. Postoperative bronchopneumonia.
(16)	20980	W	F	41	6	2–16–37			1		No	Under fascia	Sp. Nov.	Acute	Autopsy showed paralytic ileus; appendicectomy and hysterectomy; localized hemorrhagic peritonitis; no perforation of stump definite.
(17)	23497	W	M	43	6	5–17–37			1	1	No	To cavity	Sp. Nov.	Acute	Appendix removed. Postoperative pneumonia and peritonitis.
(18)	24836	C	M	14	1	7–8–37			1		No		Gen.	Perf.	Anesthetic death.

(19)	27533	W	M	63	7	10–22–37			1		No	Perito.	L. Nov.	Gang.	Autopsy showed perf. of stump with gen. purulent peritonitis; lobular penumonia; syphilitic aortitis; aortic and coronary sclerosis.
(20)	27500	W	M	26	9	10–23–37		1			No	No	Sp. Nov.	Perf.	Far advanced bilateral pulmonary tuberculosis. I and D of scrotal abscess 5 days postoperative with resultant staph. septicemia (positive blood culture).
(21)	29047	C	F	54	20	1–2–38			1		No	Perito.	Sp. Pont.	Perf.	Autopsy showed diffuse peritonitis and perforation of terminal ileum. Hysterectomy and bilateral salpingo-oophorectomy at time of oper. also.
(22)	31332	W	M	7	1	3–4–38			1		No	Perito.	Gen.	Perf.	Patient moribund on admission.
(23)	32019	W	F	20	7	4–4–38			1		No	Perito.	Sp. Nov.	Perf.	Postoperative bronchopneumonia; pelvic abscess with I and D.
(24)	32549	W	M	57	1	4–16–38			1		No	Perito.	Sp. N. & G.	Acute	
(25)	34555	C	M	29	30	7–23–38			1		Prontosil	Perito.	Sp. Pont.	Perf.	Subsequent operation for intestinal obstruction; postoperative pelvic abscess.
(26)	36298	W	M	18	1	8–21–38			1		No	Perito.	Gen.	Perf.	Massive atelectasis.
(27)	38621	W	F	50	10	11–22–38			1		No	No	Gen.	Acute	Subhepatic abscess; gangrene of anterior abdominal wall.
(28)	41117	C	M	54	3	1–22–39			1		No	Perito.	Sp. N. & G.	Perf.	Bronchopneumonia; paralytic ileus.
(29)	42889	W	F	73	1	3–14–39			1		No	Perito.	L. Nov.	Gang.	Late diffuse peritonitis.
(30)	48220	W	F	55	3	9–13–39			1		No	Perito.	Gen.	Acute	Pulmonary embolus. Sudden death.
(31)	52323	C	M	52	3	1–30–40			1		No	Fascia	L. Nov. G. & O.	Perf.	
(32)	52514	W	M	50	9	2–10–40			1		No	Perito.	Sp. Pont.	Gang.	Bilateral advanced pulmonary tuberculosis.
(33)	54349	C	F	43	4	4–7–40			1		No	No	Gen.	Gang.	
(34)	52981	W	M	45	77	5–5–40				1	No	Cavity	Sp. Nov.	Acute	Subsequent I & D of subhepatic and subdiaphragmatic abscesses; pulmonary embolism
(35)	56562	C	M	17	6	6–19–40			1		Sulfanilamide	Perito.	Sp. Pont.	Perf.	
(36)	59306	C	F	13	3	9–21–40			1		Sulfanilamide	Perito.	Gen.	Acute	Patient *in extremis* at time of operation.
(37)	63922	W	M	17	3	2–27–41				1	Sulfanilamide	Perito.	Sp. Pont.	Perf.	Subsequent generalized peritonitis.
(38)	67486	W	F	7	1	7–17–41	1				No	No	Gen.	Acute	Anesthetic death. Patient died as appendix was being amputated.
(39)	69202	C	M	44	1	10–5–41			1		No	No	Sp. Pont.		Anesthetic death. Appendix not removed.
(40)	71032	C	M	59	3	1–12–42			1		Sulfanilamide & sulfathiazole	Perito.	Gen.	Gang.	Paralytic ileus.

appendicitis that had perforation with diffuse peritonitis. From this group there were 27 deaths, with a mortality rate of approximately 31 per cent.

A review of the records of the patients reported here shows that the sulfonamide drugs have been used in nearly all perforated appendices since June, 1940. It was then that the rule was made for the administration of sulfanilamide in patients with free pus in the peritoneal cavity. There were a few instances in which it was used before that time, but only spasmodically and with no regularity in regard to the type of peritonitis or the amount of the drug.

From these statistics one might conclude that the drug has probably been an important factor in lowering the mortality rate for diffuse peritonitis, which has dropped from 31 to 19.4 per cent, and appendiceal abscess from 9.7 per cent to 3.7 per cent since its routine use. It should be borne in mind, however, that there are many factors that influence mortality and these figures should not be considered conclusive.

If these observations are significant the question arises as to the effect of the drug on the organisms causing the disease. Up to the present time that question cannot be answered satisfactorily. The chief difficulty is that the bacterial flora of the intestinal tract is not too well known nor is it constant. This is well illustrated in infancy by comparing the bacterial flora of the intestines of artificially fed and breast fed babies. The former show a richer colon and anaerobic spore-bearing group of organisms. In adult life the colon group constitutes approximately 75 per cent of the intestinal flora. Herter,[2] Kendall,[3] and Rettger[4] have done considerable research and have shown that the bacterial content of the bowel may be changed by adjusting the diet. Eggert,[5] in 1935, described 11 species of gram-positive nonsporulating anaerobes isolated from the feces. It is thought that most of these organisms are nonpathogenic, but it is also believed that some of them, under varied circumstances, may be or may become pathogenic. Whether these organisms normally present in the intestinal tract are the chief exciting factors in the causation of acute appendicitis is not known. Since the bacterial flora is altered by change in diet, acute appendicitis may be caused by some of the better known organisms that are influenced by the sulfonamide group of drugs. The sulfonamides may possibly have some inhibitory effect on the synergistic activity of two or more of the organisms in question, thereby, lessening the destructive activity formerly observed in localized or diffuse peritonitis.

The choice of sulfanilamide in preference to sulfathiazole for use in the general peritoneal cavity was made because of its greater absorptive power. One of the authors (T. B. A.) frequently has introduced from 4 to 10 Gm. of sulfanilamide into the peritoneal cavity and found that the blood level was 6 to 8 mg. per 100 cc. the following day. It would seem, therefore, to hold preference in absorptive power over all of its allied drugs. This is apparently desirable because it is thought to have little or no effect locally; however, the systemic effect is probably responsible for whatever beneficial results may

TABLE II

PATIENTS TREATED WITH SULFONAMIDES

Early Perforation		Abscess Formation		Diffuse Peritonitis	
No. of patients	26	No. of patients	27	No. of patients	29
Deaths	0	Deaths	1	Deaths	3
Mortality rate	0%	Mortality rate	3.7%	Mortality rate	10.4%

TABLE III

PATIENTS TREATED WITHOUT SULFONAMIDES:

Early Perforation		Abscess Formation		Diffuse Peritonitis	
No. of patients	56	No. of patients	31	No. of patients	87
Deaths	1	Deaths	3	Deaths	27
Mortality rate	1.8%	Mortality rate	9.7%	Mortality rate	31%

TABLE IV

AVERAGE DAYS IN HOSPITAL—WITH USE OF SULFONAMIDES

Early Perforation	Abscess Formation	Diffuse Peritonitis
13	28	23

TABLE V

AVERAGE DAYS IN HOSPITAL—WITHOUT USE OF SULFONAMIDES

Early Perforation	Abscess Formation	Diffuse Peritonitis
14	31	20

TABLE VI

MORTALITY ACCORDING TO AGE-GROUPS

Years of Age	Number of Deaths
0–10, inclusive	4
11–20, inclusive	6
21–30, inclusive	4
31–40, inclusive	4
41–50, inclusive	9
51–60, inclusive	8
61–70, inclusive	4
71–80, inclusive	1

TABLE VII

TYPES OF ANESTHETIC USED

Spinal novocaine	450
Spinal pontocaine	342
General (G.O.E.)	283
Spinal novocaine (supplemented by general or sodium pentothal	26
Spinal pontocaine (supplemented by G.O.E. or sodium pentothal)	22
Local novocaine (some supplemented with gas-oxygen,	13
Sodium pentothal (with or without gas-oxygen)	15
	1151

TABLE VIII

TOTAL PATHOLOGIC REPORTS*

Perforated appendices	80
Gangrenous appendices	76
Acute appendicitis (including suppurative cases and some gangrenous and perforated cases)	533
Subacute appendices	175
Essentially normal appendices	143
	1007

*In 144 of 1151 cases no pathologic reports are available.

follow. The same conclusion is found in the work of Meleny, and his co-workers.[6] In addition, sulfanilamide probably causes fewer intraperitoneal adhesions. This inference is based largely on the work of Boys and Lehman.[7]

The mortality rate has been reduced during the last four years in this series, and may have been influenced by the institution of sulfonamide therapy. It is not believed, however, that the rate of morbidity has been lowered to any appreciable degree. A study of Table IV will show that the average period of hospitalization has not been reduced as a result of the institution of the drug. The same observation has been made with regard to the extent of local infections.

The type of anesthesia ordinarily preferred was spinal pontocaine or novocaine. In this group of 1151 patients spinal anesthesia was employed in 840 cases and a supplement of nitrous oxide and oxygen or pentathol sodium was used in 48 instances. When spinal pontocaine was used it was mixed with 10 per cent glucose. Local novocaine, intravenous sodium pentathol, or general inhalation anesthesia was preferred in the patients who were considered in poor physical condition. This preference was expressed because of the reluctance to use spinal anesthesia in poor risks. Whenever an intrathecal injection is made a mixture of pituitrin and ephedrine is available to give before or during the period of anesthesia.

As mentioned previously, there were four anesthetic deaths in this series. Two of these occurred with the use of inhalation and two with spinal anesthesia. The anesthetic mortality rate with both types in this series was 0.3 per cent.

With regard to the pathologic studies of the 1151 cases diagnosed as acute appendicitis, there were 89 per cent which proved to be acute, and these were confirmed by microscopic examination. Of this group, 1007 were examined microscopically. Unfortunately, there can be no satisfactory conclusions drawn from the pathologic reports. This is true because a separate classification has been used in this paper. The chief interest, however, lies in the fact that of the 1007 cases examined microscopically only 143 were reported as essentially normal.

There was one patient in the group who was listed as having actinomycosis of the appendix, and one reported to be tuberculous.

A relatively large number were described as having shown evidence of *Oxyuris vermicularis*. In this group, 24 were reported with an average age of 16 years and eight months.

There were eight patients of this series in whom Meckel's diverticulum was found.

Four patients developed herniae following the operation, and all had McBurney incisions. However, it is interesting to note that all had postoperative wound infections.

CONCLUSIONS

A report of ten years' experience with acute appendicitis in a municipal institution has been presented. Six hundred and fifty-one patients were

operated upon during the first six-year period, and without the routine use of the sulfonamides where perforation had occurred. During the subsequent four-year period 500 patients were operated upon, and sulfonamides administered topically at the time of operation if such a condition existed. Following the operation sulfathiazole was given orally in nearly all such cases. The mortality rate is lower in the latter group. Further clinical and experimental studies are necessary in order to determine the value of these observations.

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DISCUSSION.—DR. M. J. HENRY, Louisville, Ky.: I should like to discuss Doctor Aycock's paper, since I recently had the opportunity to present a paper on this subject before one of our local societies. The cases I reported were operated upon by Doctor Abell, Sr., Doctor Abell, Jr., and myself. As Dr. Abell, Jr., has been working directly for Uncle Sam, while we have been doing so indirectly during most of the period covered by this study, most of the operations were performed by Doctor Abell, Sr., and myself.

In reading the current literature on the subject one is impressed with the fact that relatively large doses of the sulfonamides are used intraperitoneally. We do not use these drugs in mild cases of acute appendicitis, those in which there is slight extension of the inflammatory process to the surrounding structures. We have used the sulfonamides intraperitoneally in 134 cases, and have divided them as follows:

Acute appendicitis with local peritonitis	15
Appendicitis perforative	32
Appendicitis gangrenous	40
Appendiceal abscess	31
Peritonitis, diffuse	16

Of the 134 patients only one died. This patient was a child age eight, whose temperature was 105.8° F. on the day of operation, who died in less than 48 hours after operation. This child had a gangrenous appendix.

With very few exceptions sulfanilamide was used. Many maintain that sulfathiazole has 50 times the bacteriostatic power of sulfanilamide. We have used it rarely. Practically all cases had five grams of the drug intraperitoneally; very few received additional sulfonamide therapy through the oral or parenteral route. Not as many as five per cent received additional therapy, yet we have a mortality rate of 0.75 of one per cent.

DR. J. C. OWINGS, Baltimore, Md.: Prior to 1940 we used the sulfonamides at the Baltimore City Hospitals only very occasionally, because we had so much difficulty in preventing the drug from caking when sterilizing it. It was known that the powder contained viable spores of various organisms so that we could not use it without sterilizing it. I took this problem to the Hynson, Westcott & Dunning Company, of Baltimore, which developed a granular form of the drug put up in a sterile package that could be shaken into the wound without difficulty. Later we found that we could sterilize the granular form ourselves without any trouble.

My feeling at first was that we had found something very good and that we were going to get excellent results from local application, but in view of what the war has shown in regard to the local use of sulfonamides in open wounds, I am not at all sure of its value. At present I feel that the principal function of local application is that it provides a quick, easy and safe means of raising the blood level at a time when it is often not possible to give the drug orally because of nausea. By applying it intraperitoneally one can raise the blood level and keep it up until the patient can take the drug by mouth. The drug is readily absorbed by this route and its effect is maintained over this critical period.

Dr. Emil Novak, Baltimore, Md.: I should like to say a word about the interesting contribution of Doctor Bunch. One would get the impression from a review of the literature and also from the report which Doctor Bunch made, that perhaps two entities are embraced under the designation of mucocele. In one we deal with what, to all intents and purposes, is a retention cyst of the appendix. On the other hand, there is another condition which is embraced under this same designation, and is more likely to be encountered by the gynecologist. The mechanism seems to be different; the contents of the mucocele are not mucin but pseudomucin, chemically readily distinguishable from mucin. The epithelium is of the peculiar very tall "picket" variety which characterizes the pseudomucoid tumor of the ovary, which we believe to be a teratoma. In a teratoma we often find cysts lined with this epithelium, similar to that in mucocele of the appendix. It is embryologically interpreted as a primitive form of intestinal epithelium. That is one of the reasons we believe these cysts of the ovary are teratomata in which this entodermic tissue has blotted out all other teratomatous elements, just as thyroid tissue does in the so-called struma ovarii. The peritoneal transplants also show the tall "picket" variety of epithelium.

This, then, is a different process from the mucocele which appears to be simply a retention cyst; we deal here with a pseudoneoplastic or genuinely neoplastic process. Histologically, it is perfectly benign in all cases I have studied, but clinically such cases run an essentially malignant course. When operation is performed one can often scoop out great masses of jelly-like material, but the cells continue to secrete and the gelatinous ascites continues to recur until, often after some years, the patient dies of terminal infection or intestinal obstruction.

The point is that there appear to be two types of mucocele, but the kind of gynecologist is most interested in is that associated with pseudomucinous cystoma of the ovary. In this, the local epithelium and the character of the exudate appear to be different from that seen in the other variety.

Dr. R. M. Pool, Memphis, Tenn.: During my association with Dr. Lloyd Noland, at Fairfield, Alabama, we observed several cases of mucocele of the appendix. One of these presented several interesting features. This man was operated upon by Doctor Noland for repair of a right inguinal hernia. A mucocele of the appendix was found and removed at the same time. There was a granular tumor at the tip of the appendix and, in spite of very careful dissection, a small amount of mucoid material was spilled from this tumor. Doctor Noland recognized it and made a correct clinical diagnosis. The man was operated upon in November, 1927, and made a satisfactory operative recovery in the usual length of time. He returned in the fall of 1931, after a comfortable interval of four years. On examination it was thought that some intra-abdominal fluid could be detected, but nothing was done at that time. In 1932, he was explored because of a large accumulation of intra-abdominal fluid and because an abdominal mass could be palpated. This mass was made up almost entirely of omentum, but practically all the peritoneum was involved in a pseudomyxomatous peritonei. The patient died at home in May, 1933.

This case was followed through from the time appendicectomy was performed until the fatal termination, which was due to intestinal obstruction. The pathologic study and the second exploration verified the diagnosis of mucocele of the appendix with subsequent pseudomyxomatous peritonei.

Dr. R. L. Sanders, Memphis, Tenn.: Since Doctor Bunch was kind enough to invite me to discuss this most interesting subject, I should like to mention briefly two cases of mucocele of the appendix which have been outstanding in my memory.

The first case was reported before the Louisville meeting of this Association in 1926. The patient, a man, presented a large tumor in the right lower abdominal quadrant. The diagnosis was not made prior to operation; had the patient been a woman, I would have thought the mass an ovarian cyst. It proved to be a mucocele of the appendix measuring 39 cm. in circumference—the largest on record, so far as we could find. It had not perforated, and there were no peritoneal implants. Eighteen years have elapsed since the operation and the patient has had no further trouble. Dr. Hubert Royster was good enough to describe this case in his monograph on the appendix.

The second case was that of a woman, age about 60, who came to Dr. W. J. Mayo during my service with him in 1916. She was found to have a large fluctuating tumor below the femoral ring on the thigh. It was not unlike some of the aneurysms showed yesterday by Colonel Elkin, although there was no pulsation or other evidence of aneurysm. On opening the mass, Doctor Mayo was amazed to find an enormous amount of colloid material, which was coming through the femoral ring. He then explored the abdomen and discovered a large appendix, its tip near the femoral opening. It had perforated and its content was escaping and producing the mass on the thigh. The appendix was removed, the abdomen was closed and the thigh incision sutured. I have not had an opportunity to follow the case, so do not know the ultimate outcome. I am sure Doctor Mayo did not report it, so I am pleased to do so here and to give him the credit.

Dr. Hugh A. Gamble, Greenville, Miss.: I want to confine my remarks to the last paper. For the past 20 years I have advocated the open treatment of peritonitis due to a ruptured appendix. During this time the mortality rate has been 1.5 per cent in this class of cases. When the sulfonamides came in I found certain disadvantages. One was that it appeared to me there was more oozing in the wounds; adhesions formed more readily; and certain patients had an idiosyncrasy for these drugs. Last year I saw a patient, age 36, in good physical condition, with a ruptured appendix. We would ordinarily have expected him to recover. He was given sulfanilamide; suppression of the urine occurred and he died. I feel that his death was due directly to the drug and that a word of warning should be issued as to the danger incident to its use. I do not feel that the sulfonamides are cure-alls. They have not helped our mortality rate one iota.

Under the open treatment the mortality rate in these ruptured and complicated cases has ranged consistently around 1.5 per cent. All the patients who died have been more than 65 years of age, with the above exception; some were as old as 85, and many were diabetics. I am definitely assured that we can still keep our mortality rate low without the employment of sulfonamides.

Dr. Henry W. Cave, New York, N. Y.: This discussion on the use of sulfonamides, particularly sulfanilamide in its relation to acute suppurative appendicitis, could go on and on indefinitely.

At the Roosevelt Hospital in New York, where we have been interested in the use of this drug intraperitoneally since January 10, 1940—almost five years ago—Dr. Sterling Mueller poured an undertermined amount of sulfanilamide into the perintoneal cavity in a patient who had a ruptured appendix, with diffuse peritonitis. This patient made a very satisfactory recovery. Since that time we have operated upon 1,000 cases of acute appendicitis, and of this number three have died. In this group we have used sulfanilamide intraperitoneally in about 40 per cent, reserving it for the severe cases.

In the five-year period prior to January 10, 1940, we operated upon approximately 850 patients with acute appendicitis, diagnosed microscopically, and in this group 21 deaths occurred.

We believe it is advantageous to use sulfanilamide intraperitoneally in acute inflammatory lesions of the appendix. We have had two experiences with marked jaundice in patients following administration of 10 mg. and 8 mg., respectively. So far as drainage is concerned, we have used drains in 35 per cent of all cases in which sulfanilamide has been used.

Dr. Hubert A. Royster, Raleigh, N. C.: I think Doctor Novak has hit the mark in his discussion on different kinds of cysts of the appendix. They vary all the way from so-called retention cysts up to pseudomucinous cysts. We need to consider the pathologic

origin and the location of these cysts. Many of us have encountered small cysts of the appendix under the serosa that have nothing to do with the interior; they are quite common, and have no pathologic significance. On the other hand, cysts inside the appendix of varying size, whether from the mucosa or submucosa, I think represent a degenerative process. In the pseudomucinous cysts we have an entirely different process, classed as an abnormal type, misplaced tissue, and, therefore, coming under the head of teratomata.

In my book (1937) I gave a review of cysts of the appendix including mucocele, if they are harmless, retention cysts or what you please, but the pathologic definition is the discriminating question which applies as we see them clinically. I feel this distinction should be made before we classify any we may see, small or large, which are not simple cysts but teratomata. I think the size of the cyst is important, when it comes to the pseudomucinous variety. I had the pleasure of reproducing Doctor Sanders' illustration in my book, and gave him credit for the largest on record. I have seen none since as large or larger.

Having been retired for six years, I look back on our mortality rate in appendicitis. For several years preceding our retirement we had a mortality of about 1.5 per cent over the years, and recently I expressed myself to my colleagues as wondering if the improvement since the introduction of the sulfonamides were due to the drug itself or due to good judgment and technic in the operation. I cannot feel that if a man has been operating for 20 years his technic should not improve. I do not think we can attribute all the improvement to the drugs. It is a sad thing that I had to get out before the sulfonamides were invented; I might have assumed none of my patients would die; that to be immortal one should have appendicitis and be operated upon.

Dr. George H. Bunch, Columbia, S. C. (closing): I deeply appreciate the discussion. I wish to thank Doctor Novak for informing us that some adenomatous cysts of the ovary are in reality teratomata. True peritoneal transplants have not been recognized in the cases of pseudomyxomatous peritonei reported by me. The cells have not been invasive and masses of adherent pseudomucin could be removed from the peritoneal surface without grossly impairing its integrity.

Dr. Thomas B. Aycock, Baltimore, Md. (closing): I greatly appreciate the discussion given this paper. As to the dosage of sulfanilamide, referred to by Doctor Henry, we rarely place more than eight grams in the peritoneal cavity at the time of operation; more frequently we use four or five grams. I think Doctor Owings and Doctor Royster hit the nail on the head in their comment. I do not think any of us are sure where we stand regarding this question—particularly as to the local use in acute appendicitis with peritonitis. I realize, as Doctor Gamble said, that there are dangers in the use of this drug, and we are always on the lookout; blood levels are taken daily in these patients, and always the day following local administration.

SACRAL AND PRESACRAL TUMORS*

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TUMORS which originate in and ventral to the sacrum are so rarely seen that individual experience pertaining to such neoplasms naturally is limited. However, some three years ago, within a period of fourteen months, I encountered three tumors of this region which stimulated my study of new growths of this location. One of these growths was a chordoma; another was an ependymal cell glioma, and a third was a large dermoid cyst.

A few general remarks referable to tumors of this location will be made as a background for the discussion and a brief report of these three cases will be presented. The paper will emphasize primarily the treatment and prognosis of malignant lesions of this region.

The neoplasms of this location are of many pathologic types and usually arise from vestigial embryonic tissue. The potentialities of the sacrococcygeal region are based on the fact that the primitive node occurs here; and from it all the fundamental systems of the body grow forward. During fetal life this remains for a long time a point of fusion of the central nervous system, skeletal axis, segmental musculature and postanal gut. Along the primitive gut wall migrate the primitive cells of the gonad. There are more possibilities here than almost any place in the body. The tumors encountered most frequently in this region are chordomas, dermoids, ependymomas, teratomas, Ewing's tumors, giant cell tumors, neurofibromas and fibrosarcomas. The majority of the malignant lesions will be found to be chordomas, ependymomas, fibrosarcomas, malignant changes in the benign neoplasms of this region and metastases from primary malignancies elsewhere.

The chordoma is probably the most interesting tumor occurring here. It is a neoplasm arising from the cellular remains of the notochord and, therefore, is composed of epithelial tissue. In 1858, Mueller was the first to advance the view that these tumors were of notochordal origin. In 1894, Ribbert confirmed the opinions of Mueller and was the first to apply the name of chordoma to this growth. This was fifty years ago.

The first recorded cases of sacrococcygeal chordomas of clinical interest were those reported by Feldmann and by Mazzia in 1910. According to Mabrey, Wood reported the first sacrococcygeal chordoma in the American literature in 1913. Stewart, in 1922, presented an excellent paper on chordomas and reviewed the literature up to that date. He found only twenty-six such cases in the literature. In 1935, Mabrey again reviewed the literature pertaining to these tumors and found at that time 150 recorded cases of chordoma. Faust, *et al.*, in a recent article, submitted 102 additional

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cases of chordoma in the literature. This brings the total number of cases reported to 252 in these two communications.

Most chordomas are situated in the sacral region. The next most frequent site is the spheno-occipital region, although a few cases have been reported along the vertebral column at various levels.

Chordoma may develop at any age. Montgomery and Wolman reported such a tumor in an infant three and one-half months of age; and the oldest case that Chesky found in the literature was in a man age seventy-nine. Dickson and Lamb stated that the average age at the onset of chordomas of this region is from thirty-five to forty years of age, and that males are twice as prone as females to develop these neoplasms. Trauma is considered an etiologic factor in many instances.

Presacral dermoids constitute a fair percentage of the tumors of this region. Whittaker and Pemberton, in a study of twenty-two cases of presacral tumors, reported that nine of them were dermoids.

Presacral dermoids arise from the ectodermal layer. According to Carney, it is possible that dermoids may derive from either of three structures: proctodeal membrane, postanal gut or vestiges of the neurenteric canal.

They may occur at any age. Manheim and his group stated that no incidence of a presacral dermoid has been found in the male.

Dermoid cysts are usually encapsulated, have a poor blood supply and may compress, but do not invade, adjacent structures. Thomason emphasized that sinus openings in the sacrococcygeal region are usually the external manifestations of cysts or tumors of developmental origin. Lahey and Eckerson concluded that a presacral dermoid should be suspected in patients who have sinuses and abscesses about the anus and who have had repeated operations.

Ependymal cells in the early embryo form a large part of the neural tube. Ependymal gliomas of the sacrococcygeal region arise from remnants of embryologic structures forming the lower end of the spinal cord, the filum terminale, and grow as localized neoplasms destroying bone by erosion. It is the neoplasm which derives most frequently within the sacral canal.

The symptoms produced by early and small growths of this region are usually negligible; whereas those caused by large tumors may be pronounced and disabling. The symptoms are not modified materially by the pathologic histology of the neoplasm because the symptoms of tumors of this region are usually those directly the result of mechanical pressure, that is, pain and anesthesia of variable degrees. This is influenced directly by the size, location, degree of erosion or invasion of bone and extension of the neoplasm. Pain is usually more pronounced in those cases in which the tumor began within or has invaded the bone. Large tumors of this region may cause marked impairment of the functions of the rectum and bladder because of encroachment. This results in the usual symptoms.

A digital examination of the rectum is the most essential part of the

physical examination. The presence of a tumor which displaces the rectum and other pelvic structures anteriorly can be palpated by a rectal examination. The size, contour, consistency and mobility of the tumor can also be ascertained by a digital examination. Roentgenologic findings may be negative or may show erosion, destruction or invasion of the bone. The final diagnosis of the nature of the tumor depends on a microscopic study of tissue from the neoplasm.

Location of the tumor, duration of the growth, size of the neoplasm, degree of extension of the tumor to adjacent structures and pathology of the lesion are factors which modify the treatment and prognosis. The completeness of removal of the tumor and the surgical instrument used for the excision definitely influence the prognosis.

Chordomas of this region occur in one of three locations in relation to the sacrum. The tumor may be retrosacral, within the sacral bone or in, or on, the anterior surface of the sacrococcygeal bones. The most frequent site is in, or on, the anterior sacral wall with the tumor extending forward into the hollow of the sacrum. Adson, Moersch and Kernohan, in a review of nineteen cases of chordomas, found that seventeen originated in the sacrum, involved it and extended into the pelvis. One tumor developed in the sacrum but did not extend into the pelvis; and one developed anterior to the sacrum but did not invade the sacrum. Mabrey reported the incidence of eighty-seven cases of sacrococcygeal chordoma in various regions to be: antesacral 41, retrosacral 29, and central 17.

The duration of the growth naturally influences the size and extent of the neoplasm. According to the case histories, the majority of these tumors have been present for a few years before the patients have come for treatment.

Mabrey found in sacrococcygeal chordomas that the average duration of symptoms before treatment in seventy-seven cases was 35.7 months, or approximately three years. Adson, Moersch and Kernohan reported this figure to be thirteen months. In the case we are reporting, the patient began to have symptoms some five years before admission to the Clinic.

Whereas these tumors are rather slow in growth, some develop to an enormous size. Hsieh and Hsieh reported a chordoma of the gluteal region 20 x 20 x 15 cm. Stewart and Morin reported a tumor 30 x 20 cm. and another 26 x 22 x 15 cm. The fact that the symptoms of early disease are negligible probably largely accounts for the long history of the presence of a tumor and explains why the tumor is frequently of large size when a patient comes for treatment. The larger the tumor, the more difficult is its exposure, mobilization and removal. The size and duration of the growth naturally have a bearing on the extent of the lesion. Early and small lesions are usually found somewhat encapsulated, are more amenable to surgical removal and have a better prognosis.

PATHOLOGY

The pathology of the malignant lesion definitely influences treatment

and prognosis. Tumors arising in vestigial structures always present problems in pathologic diagnosis because of their infrequency and because their structure often presents either bizarre cellular pictures of unusual cellular types or mixtures of them. The anatomic sites of these neoplasms may help to identify them.

Chordomas are soft tumors. Their chief histologic features are rounded cells growing in cords and having vacuoles in their cytoplasms or nuclei, accompanied by abundant mucinous material. Sometimes they resemble the structure of material from the nuclei pulposi of the spinal column. Most chordomas are slow in growth and have a low degree of cellular activity. As the tumor develops, there seems to be a predilection to an extension of the growth along the course of the blood vessels and into the adjacent muscles and nerves with an invasion of the bones of this region, rather than a spread of disease by way of the lymphatics. The rectum and peritoneum are seldom invaded by the neoplasm. These tumors rarely metastasize until late in the disease. However, Mabrey found in a review of sixteen autopsies that metastasis was present in 62 per cent of the cases. The discouraging fact is that these neoplasms do have a marked tendency to recur locally because of the difficulty of complete, primary extirpation of the disease.

Ependymal gliomas occurring here usually simulate closely the cellular pictures of well differentiated gliomas of the brain, in that the cells are evenly rounded, stain well and regularly, have distinct nuclei with sufficient cytoplasm, have a few, light, fibrous trabeculae and show little tendency toward glial fibril formation. Ependymal cell gliomas are local, do not tend to metastasize, may show recurrence and usually are of a fairly low degree of malignancy.

The dermoid cysts of the presacral area are hard to explain on the basis of anything but vestigial structures. Tumors of this type are identified by epidermoid tissues, are frequently cystic and slow in growth. Some are teratoid and malignant.

SURGICAL TREATMENT

The tumors predominating in this region are either benign or are malignant neoplasms with a low degree of cellular activity. A good result can be expected when a benign neoplasm has been removed completely; and low grade malignant tumors should not recur when removed by extending the line of excision well beyond diseased tissue and leaving the field free from contamination by malignant cells.

However, practically all reports concerning the cure of chordomas are discouraging. This is emphasized by the following observations made by various writers. According to Montgomery and Wolman: "The ideal treatment for a chordoma is complete surgical extirpation. This is almost always impossible. It is questionable whether any patient has been permanently cured by operation or irradiation." Chesky stated that the prospect for

complete eradication of the tumor is extremely bad. All patients operated upon, except those seen in recent years, have died of a recurrence. Fletcher, Woltman and Adson pointed out that complete surgical removal of most chordomas is practically impossible. Keane reported that a chordoma is an invariably fatal tumor. Whittaker and Pemberton found the incidence of recurrence is quite high and, if local, is usually due to an incomplete removal of the original growth. Bell stated that no permanent cures of chordoma have been reported. Stewart gave the incidence of local recurrence as 86.5 per cent; and according to Stewart and Morin, thirteen cases out of fifteen who survived surgery are known to have developed a recurrence.

Notwithstanding these discouraging reports, an occasional patient has been known to be alive and apparently free of disease many years after the excision of the neoplasm. Garlock reported a case apparently well ten years after surgery.

A posterior approach with an incision over the sacrum and coccyx extending to near the anus affords the best exposure to tumors of this region. The patient should be in the Kraske position. The coccyx and as much of the sacrum below the sacro-iliac articulation as is necessary for adequate exposure of the neoplasm should be removed.

It is fortunate that a majority of the chordomas of this region occur in the lower part of the sacrum and coccyx, as reported by Mixter and Mixter, for tumors so located are more accessible for removal. Furthermore, it is the opinion of Mixter and Mixter that a rather wide excision of the bones, muscles and nerves of this region should be done when such is necessary for the complete eradication of the disease. They have shown that the segment of the sacrum below the sacro-iliac articulation, together with the coccyx and all of the sacral nerves except the first and second, can be removed without severe disability being incurred by the patient. Bowers confirms the opinion of Mixter.

Wide, radical excision appears logical to me; for although these structures are important, they are not essential to life and well-being. Hence, there should be no hesitancy in sacrificing these tissues when necessary for complete eradication of the disease, inasmuch, as only the entire removal of all diseased tissue offers to the patient a probability of cure.

It is an established fact that the cure of a malignancy depends largely on what is done at the time of the first operation. Malignancies that recur may be retarded in their growth and spread, but are seldom cured by an additional surgical procedure. So again, I would emphasize the importance of making every effort to eradicate completely the disease at the time of the initial operation. All low-grade malignancies that tend to recur locally require a much more difficult procedure with less probability of cure following the second or third excision than would have been necessary at the time of the initial operation.

In keeping with the teaching of my preceptor, Dr. A. C. Scott, Sr., I am convinced that more certain, complete removal of all these low-grade lesions

is attained by the use of the cautery knife for the cutting of all soft tissue, followed by thoroughly baking the bone margin after the removal of all apparently diseased bone. This prevents the transplantation of malignant cells on a raw margin of bone. All regional bony crevices and foramina should also be baked by the cautery in an attempt to destroy all malignant cells burrowing into these regions.

Although I am reporting only two cases of low-grade malignancy of this region so treated, we have found this plan of management favorable in the

FIG. 1.—Roentgenogram demonstrating destruction of the lower segment of the sacrum and coccyx, with irregular bone margins which indicate an infiltrating type of bone malignancy—chordoma.

treatment of many neoplasms of low degree of cellular activity elsewhere in the body, such as extensively infiltrating basal cell epitheliomas and fibrosarcomas. The cure of such malignancies depends almost entirely on complete local excision or destruction of the disease. It has been our custom to gauge the extent of the excision of such tumors by taking a section for immediate pathologic study from the margin of the excised structures. Any time the frozen section shows the line of excision approaches or extends into diseased tissue, the line of excision is modified, when possible, and extended more widely into healthy tissues.

REPORT OF CASES

Case 1.—Chordoma. A 44-year-old white female came to the Clinic May 5, 1941. She stated that five years previously she had fallen and injured her coccyx. Since then she had been bothered by a growth beneath the skin over the sacrum. There was no drainage from the growth.

On rectal examination, there was felt a nontender, nodular mass of restricted mobility. It extended from the lower portion of the coccyx up a few centimeters beyond

the lower margin of the sacrum, thus, making a mass in this region approximately 12 cm. in diameter. Laboratory studies revealed essentially negative findings. Roentgenologic examination of the pelvis disclosed that the coccyx and the lower segment of the sacrum had been destroyed by a neoplasm which was thought to be a primary bone tumor (Fig. 1.)

On May 8, 1941, the patient came to surgery. She was placed in the Kraske position and an incision was made with the cautery knife over the sacrum to within about 2 cm. of the anus. The skin flaps were reflected widely and the muscles attached to the lower portion of the sacrum and coccyx were severed approximately 7 cm. lateral to these bones. The tumor was thus exposed. It was gelatinoid in appearance, and had

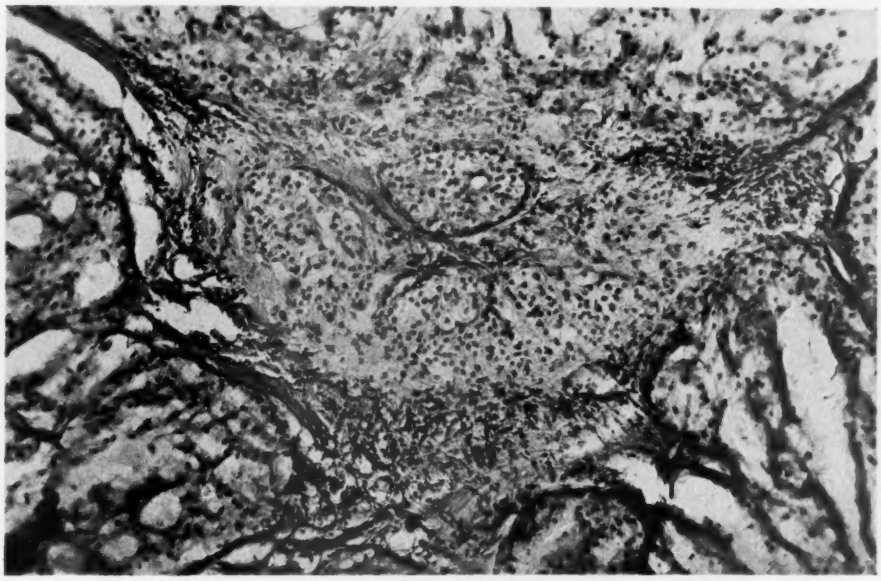


FIG. 2.—Photomicrograph of chordoma from the sacrococcygeal region.

apparently destroyed the coccyx and infiltrated the lower portion of the sacrum. The lower two sacral vertebrae and the coccyx were removed with bone forceps and then the tumor was excised by means of the cautery knife. The exposed sacral bone and the margins and base of the wound were then baked with the cautery. The wound was partially closed after packing the depth of the wound with gauze. The tumor was 12 x 11 x 10 cm. and weighed 312 Gm. It was encapsulated, soft and largely filled with gelatinoid material showing few cells. Along numerous fibrous partitions present there were more cells, which were large, clear, pale-staining and sometimes vacuolated. From a strictly histologic viewpoint, this tumor was difficult to classify; but by position, behavior and structure, it was considered to be a chordoma of a low degree of malignancy. The pathologic report was malignant chordoma from the sacrococcygeal region (Fig. 2).

From May 23 to June 5, 1941, the patient was given a series of roentgen therapy, the total dosage being 1368 r. to the skin.

Three months later she reported for check-up. She had a sinus in the sacrococcygeal region which led down to the bone. A sequestrotomy was performed and the sinus was curetted. Tissue which was removed was reported as benign by the pathologist. A second series of roentgen therapy was given, the total dosage being 2000 r.

The sacrococcygeal sinus was curetted and packed on two later check-ups, in January and in May of 1942.

The patient has returned regularly for observation and was last seen here September 13, 1944, then more than three years since the removal of the tumor. At that time her condition was satisfactory and by physical and roentgenologic examination there was no evidence of recurrence (Fig. 3).

Case 2.—Ependymal cell glioma. A white female, age 32, was first seen here on June 30, 1941. For some two years she had had a swelling in the region of the lower portion of the vertebral column. It was tender and caused a dull aching in this region. The symptoms were aggravated by stooping.

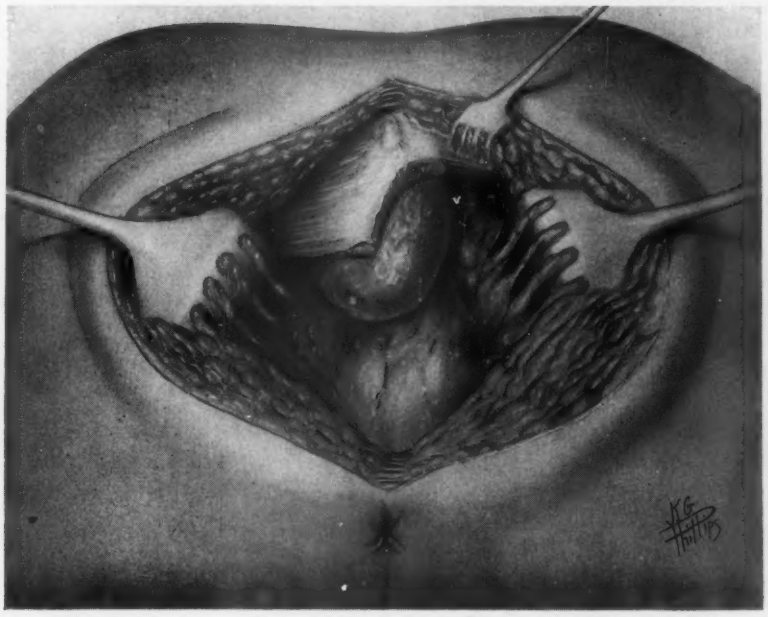
On examination, a hard mass about 5 cm. in diameter was present posterior to the vaginal vault. It was found, fairly smooth, not very tender, and of rather markedly

FIG. 3.—Roentgenogram revealing postoperative resection of the lower portion of the sacrum and coccyx, smooth bone margins and no evidence of recurrence of chordoma.

restricted mobility. By rectal examination it was apparently posterior to the rectum, about 5 cm. above the coccyx. The remainder of the physical examination was negative. Laboratory reports were essentially negative. Negative findings were reported following roentgenologic examination of the lumbar spine, pelvis and hips. The final preoperative diagnosis made was of a tumor posterior to the rectum and of probable malignancy.

On July 3, 1941, with the patient in the Kraske position, a cautery knife incision was made over the lower portion of the sacrum and coccyx, the incision extending almost down to the anus. The tumor, 10 x 12 cm. in its larger diameter, was exposed anterior to the sacrococcygeal articulation (Fig. 4*a* and 4*b*). The coccyx and the lower segment of the sacrum were removed. The tumor was well encapsulated except for attachment to the anterior surfaces of the sacrum and coccyx. It was dissected from these by means of the cautery knife and then its attachments in this

A



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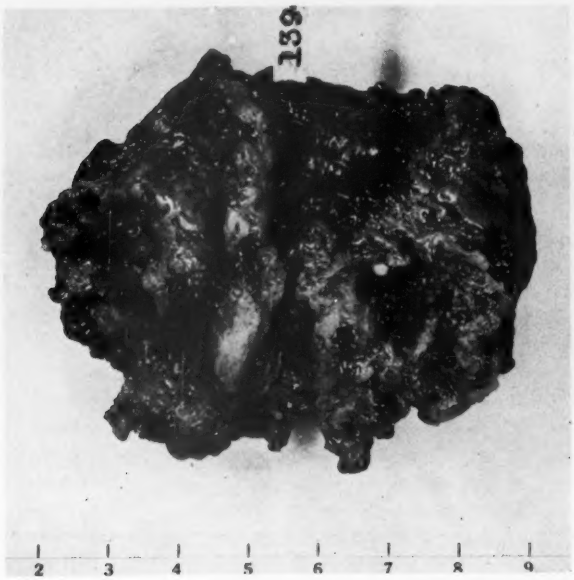

FIG. 4.—A. Drawing of ependymal cell glioma after exposure for surgical removal. B. Specimen of ependymal cell glioma after removal.

region were thoroughly baked by use of cautery. The excision of the tumor was then completed with the cautery knife. The tumor measured approximately 7 x 5 x 3 cm. It was smooth, fibrous and encapsulated and had a bluish color on the cut surface. The specimen weighed 24 Gm. Sections showed a very cellular neoplasm in which there was an abundant intercellular stroma with many areas of degeneration. The pathologic report was of partially degenerated and infected ependymal cell glioma, Grade I (Fig. 5).

She was given two series of roentgen therapy, a total of 2736 r. being administered.

She returned for observation November 19, 1941, four months following surgery. At that time a sequestrotomy was performed and the sinus curetted. The pathologist reported that sections showed only subacute inflammatory tissue.

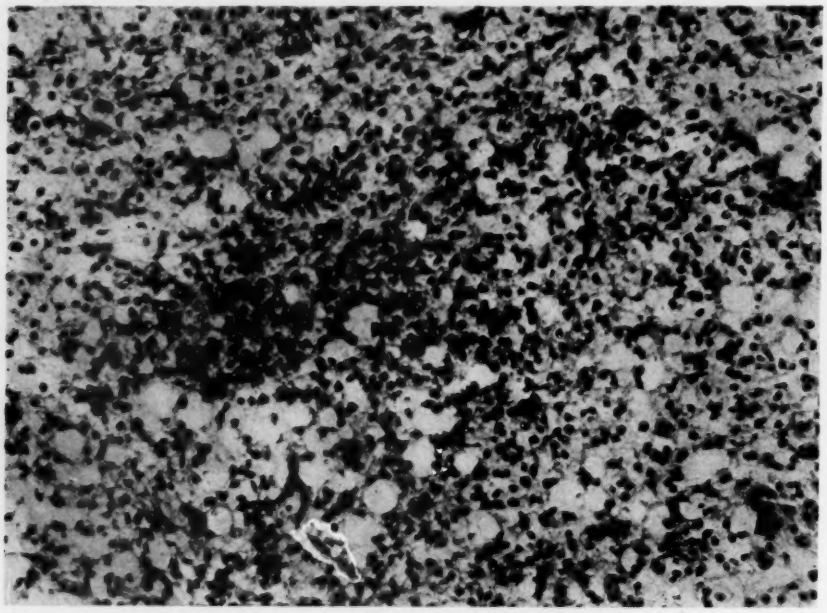

FIG. 5.—Photomicrograph of partially degenerated and infected ependymal cell glioma, Grade I.

The patient returned on June 28, 1943, two years after her primary surgery, complaining of pain in the right buttock region radiating down the right thigh. By rectal examination there could be palpated a mass about 4 cm. in diameter anterior to the lower sacrum. Roentgenologic examination showed extension of the malignant process involving the right half of the sacrum up to the level of the sacro-iliac joint (Fig. 6). With the patient in Kraske position, an incision was made over the lower portion of the sacrum and practically all of the sacrum below the sacro-iliac joint on the right was removed and the recurrent tumor mass, some 15 cm. in diameter, was excised by means of cautery. After excision of the tumor, the margins of the bone and base and the lateral margins of the wound were thoroughly baked with cautery. A third series of roentgen therapy was administered, using a dosage of 1368 r.

The patient returned for observation in February, 1944, at which time a sequestrum was removed. She was last seen here in September, 1944, fifteen months after the excision of the recurrent malignancy. At that time her condition was fairly good. There was no impairment of control of the bladder or anal sphincter. Roentgenologic examination of the sacrum revealed no evidence of malignancy in the bone (Fig. 7). There were no enlarged nodes over the body. Rectal examination was negative.

Case 3.—Dermoid cyst. The patient, a white female, age 36, reported to the Clinic June 29, 1942. Her chief complaint was of dull, aching and burning pain in the region of the coccyx which had been present for approximately two years.

FIG. 6

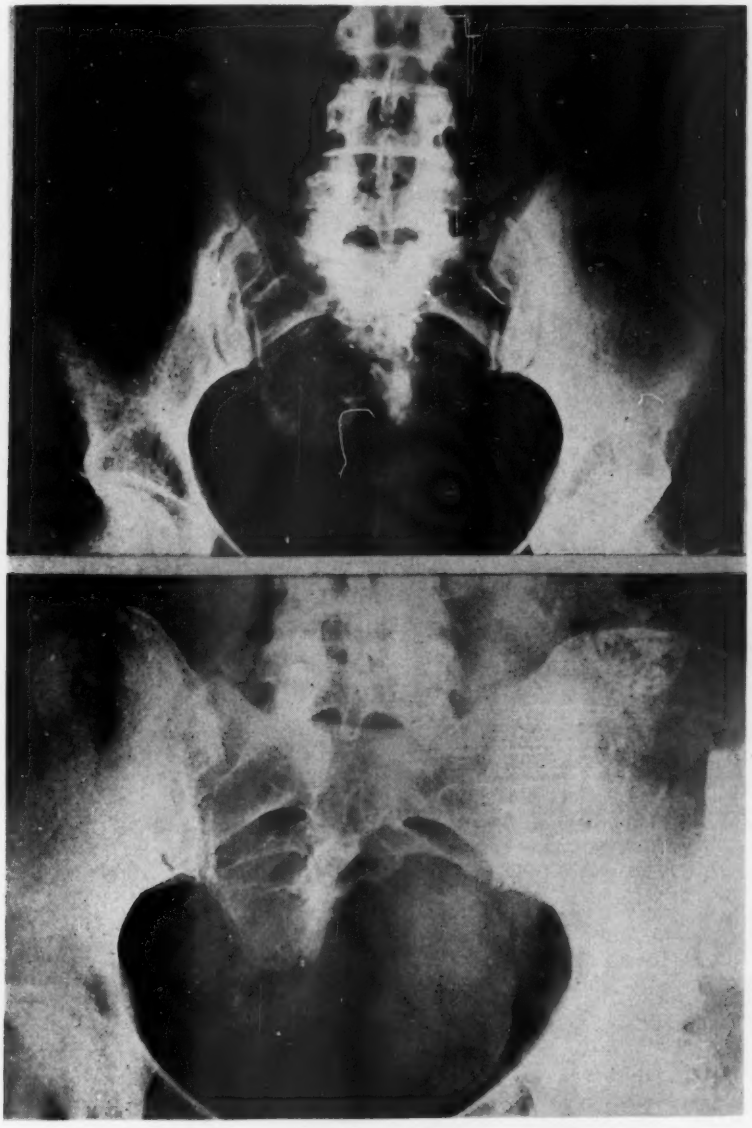

FIG. 7

FIG. 6.—Recurrence of the ependymal cell glioma two years after the primary excision.
FIG. 7.—Roentgenogram made 15 months later shows no evidence of recurrence of ependymal cell glioma.

On physical examination, a mass 10 to 12 cm. in its long axis and 6 to 8 cm. in its transverse diameter was present posterior to the rectum and anterior to the coccyx and lower sacrum. It was irregular, fairly firm, of restricted mobility and not par-

FIG. 8.—Specimen of sacrococcygeal dermoid cyst.

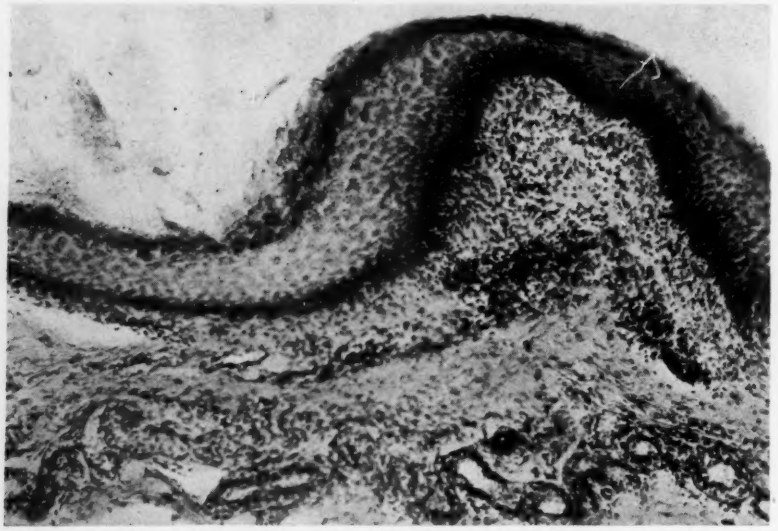

FIG. 9.—Photomicrograph of sacrococcygeal dermoid cyst.

ticularly tender. Findings of laboratory studies were essentially negative. Roentgenologic examination revealed the sacrum and coccyx were negative. A preoperative diagnosis was made of a tumor of the coccygeal region, probably a chordoma.

She went to surgery on July 9, 1942. With the patient in the Kraske position, an incision was made extending from the midsacrum down to within about 2 cm. of the anus. The coccyx and a small portion of the adjacent sacrum were removed. The tumor mass was excised by means of cautery knife and the wound was closed with a drain. The tumor measured 7.5 x 5 x 3.5 cm. and weighed 31 Gm. (Fig. 8). Examination showed a multicystic process with one large space and a number of smaller ones filled with thick putty-colored material of nongreasy type. The lining of most of the spaces was modified epidermis with an occasional accessory structure such as sweat and sebaceous glands. No hair follicles were discovered. The pathologic report on the tissue removed from the sacrococcygeal region was dermoid cysts (Fig. 9).

The patient was dismissed on July 28, 1942, and was last seen here August 18, 1942, at which time her condition was satisfactory.

COMMENT.—In the case of the chordoma, complete removal was possible because the chordoma was relatively small. Emphasis is placed on the value of excising widely primary malignancies of low grade which do not tend to metastasize. The use of the cautery knife for the excision is believed to have been a factor in the results obtained in this case. It is my opinion that this patient will probably remain well.

The case of ependymal cell glioma emphasizes the necessity of removing widely all malignant tissue at the time of the primary operation. Certainly a more radical removal of the neoplasm should have been done when the initial operation was performed. Furthermore, even though such a patient develops a recurrence of disease, by a second surgical procedure it may still be possible to eradicate all diseased tissue and thereby cure the patient.

The case of the presacral dermoid indicates that a good result may be expected when the complete removal of a benign neoplasm has been accomplished.

SUMMARY

A majority of the chordomas and ependymomas are malignant lesions of low degree of cellular activity. They tend to recur locally rather than by distant metastasis. According to the histories of reported cases, most chordomas develop a local recurrence. The operative notes for some of these cases state that all apparently malignant tissue was removed by a curette. Curetting a malignant lesion rarely, if ever, results in a cure. The ideal to be attained by the surgical procedure is an initial, complete surgical extirpation of the neoplasm leaving the field free from contamination by transplanted malignant cells. Due appreciation of adequate exposure is important. The sacrifice of important structures must be accepted when necessary for the complete eradication of disease. Much of the lower portion of the sacrum, the coccyx, the lower three sacral nerves and the muscles of this region can be removed without causing severe disability. Recognition of this fact should lead to more radical primary excision of the operable lesions. The use of the cautery knife as the agent for the excision definitely

increases the probability of leaving the field free of transplanted malignant cells. Surgical treatment for these neoplasms based on the above facts will result in a smaller percentage of local recurrence and also will definitely increase the number of patients cured.

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DISCUSSION.—DR. GEORGE E. BENNETT, Baltimore, Md.: As I look over the audience I am very sorry to see that so few orthopedic surgeons have come in to hear this paper. They would learn something if they were present because, by and large, I think we see these cases earlier than the surgeons do. As you know, orthopedic surgeons are a clearing house for pain, regardless of where the pain is. It has been my privilege to have diagnosed a great many of these presacral and other types of sacral tumors, and I have been much interested in the subject. Sacral pain and pain referred to the buttocks often proves to be due to tumors developing in the presacral and sacral region. I do not think that orthopedic surgeons, or you as surgeons, should pass up a rectal examination in cases with obscure pain about the sacrum. A tumor developing in the posterior part of the sacrum is a problem which should be given serious thought with regard to diagnosis. When there is indefinite pain about the sacrum with rather bizarre neurologic signs, or no neurologic signs, the first thing to look for is a presacral, sacral or cauda equina tumor. Some years ago I reported a series of cases of cauda equina tumors and called attention to the fact that often the first symptom noted by the physician or surgeon is spasm of the erector spinae and hamstring muscles. I do not think this is a subject that we can pass superficially.

DR. W. J. MIXTER, Boston, Mass.: This is a very interesting paper; not only that, but Dr. Bennett has added much to the discussion by his remarks. I remember his paper which was read in Washington, I believe, and which helped me a great deal.

It seems to me that Doctor Brindley has fixed our attention on a small group of tumors which, as a rule, are neglected until pretty late in their history. He has picked up three of these, one in a very early stage, for which he is much to be congratulated. Most chordomas are higher, but this was low enough to lend itself to complete excision. All you can do for most of these is to make a hole and scoop the tumor out and they come back, and that is eminently unsatisfactory surgery. He has a cure, and I believe it is going to be complete. I wish I could say as much. I have one case alive that we hope will be a cure, but I doubt it.

There is an interesting group of chordomas of the lower lumbar spine which are sometimes overlooked; many are called hemangiomas. It is impossible to eradicate these growths, but they may be treated at times by partial excision, fusion and irradiation.

DR. JOHN C. A. GERSTER, New York, N. Y.: I should like to report two cases: The first was a man, aged 64, a surgeon, who, seven years previously had had an episode of left-sided pain, what he thought was a renal colic. As a sequela of this attack he had paresthesia of the left great toe and, as time went on, this spread to the anterior crural nerve distribution. Being a teacher of anatomy, he followed the spread and distribution of pain very carefully. Finally, there was painful paresthesia of the entire left lower extremity, left testis and left half of the penis. He sought advice from different clinics, east and west and, finally, was seen in New York by a well known, careful neurologist, who thought he had a lesion involving the cauda equina. Some weeks later at a neurologic hospital the cauda equina was explored and nothing was found. Several months later, the symptoms continuing, at his own demand, a chordotomy was performed; however, although there was anesthesia to pinprick over the left lower extremity and left lower half of the abdomen, he still suffered agonizing pain—apparently the chordotomy was not high enough.

Finally, one day the patient himself pulled on a glove, made a rectal examination and felt a mass; it was a huge tumor filling practically three-fourths of the pelvis. Films of the pelvis, made on November 11, 1939, showed a considerable amount of irregular bone destruction in the left side of the pelvis. The ilium has been partially destroyed above and medial to the acetabulum. The left ischium and the lateral portion of the left pubic ramus are also involved in the destructive lesion. A large soft tissue mass is present almost filling the left side of the pelvis."

The patient demanded that something be done, even if it were an interilio-abdominal amputation. At another general hospital, as a preliminary step, a Devine colostomy was established. A few days later he had myocardial failure and died. At autopsy there was found "a sarcoma involving the nerves of the sacral plexus filling the left half of the pelvic cavity and extending into the guteal region"—apparently a neurogenic sarcoma

arising from the sacral plexus. It took the pathologist 45 minutes to get out the specimen. It is doubtful whether surgical removal could have been accomplished. The lungs were free of metastases. My only connection with the case was when, after the tumor's discovery, a trial (under my direction) was given the so-called frozen sleep—crymotherapy*—for relief of his pain. The result was unsatisfactory.

The second case was that of a man, age 64, who had pain only for five or six weeks. Digital examination of the rectum showed an elastic mass in the hollow of the sacrum. Films of the pelvis and colon, made in November, 1944, show "an irregular area of bone destruction approximately 4 cm. in diameter situated in the lower portion of the body of the sacrum slightly to the right of midline. A large soft tissue mass lies anterior to this portion of the sacrum and displaces the rectal ampulla anteriorly for a distance of about 5 or 6 cm. Films of the chest show an area of infiltration at the upper portion of the left hilum which apparently represents neoplastic involvement."

In spite of the fact that he had obviously a long-standing involvement, there was only a five weeks' history of symptoms. At a subsequent exploratory celiotomy, the upper border of the tumor was found to be just below the pelvic brim. There were metastatic nodules in the dome and along the free margin of the liver.

The relative rarity of presacral tumors has prompted the reporting of these two cases.

Dr. G. W. N. Eggers, Galveston, Texas: I had the opportunity to speak to Doctor Brindley some time ago about these tumors, and I had a case which he requested me to mention today, which is interesting from a diagnostic standpoint. It was a very destructive lesion involving the sacrum. The patient was a young woman who had been advised to have various types of pelvic operative intervention. She had destruction of about two-thirds of the sacrum. The usual roentgenograms of the chest and skull were made, with negative results, and she was advised to have the sacral tumor explored.

I changed the approach a little, making a Y-shaped incision with a transverse incision at the level of the second sacral (that is quite safe) until a positive diagnosis was made. It proved to be a very extensive giant cell tumor from the sacrum itself. The woman was given roentgenotherapy; and regression of the tumor is taking place slowly. One should be cautious in the diagnosis of these sacral tumors.

Dr. G. V. Brindley, Temple, Texas (closing): I appreciate these discussions because I know they have emphasized some very important facts. In concluding the discussion I would stess the importance of a complete physical examination and particularly a rectal examination. In a review of the literature it was observed that practically all these tumors had been present for three or five years, or more, when they came to surgery. Certainly, many should have been diagnosed earlier. Had this been done it is probable that more would have been resectable and curable.

Also, I would emphasize due appreciation of adequate exposure even though it necessitates the sacrifice of important structures, recognizing that it is better to accept some impairment of function and disability to obtain a cure. Finally, I would urge the use of the cautery knife for the excision, believing that by its adoption there will be a definitely increased probability of leaving the field free from contamination by malignant cells.

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TREATMENT OF VARICOSE VEINS BY STRIPPING, EXCISION AND EVULSION

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THE CONVENTIONAL MANAGEMENT of varicose veins by high ligation and by injection sclerosis although usually effective has been associated with certain complications and limitations. Local slough, periphlebitis, allergic reaction, deep vein thrombosis, and pulmonary embolism have been reported by Faxon and Barrow,[1] Atlas,[2] and others. Painful leg edema and reflex vascular spasm occasionally develop. G. de Takats,[3] Howard,[4] Faxon and Barrow,[1] Ochsner and Mahorner,[5, 6] and Sarma[7] report an incidence of recurrence following combined saphenous ligation and injection therapy of 10.8 to 23 per cent. A period varying from several weeks to many months is often necessary for such satisfactory injection obliteration. Certain patients become discouraged and fail to return for adequate treatment. The incidence of recurrence after injection alone has been between 60 and 98 per cent (Howard, Jackson and Mahon[4] and Ochsner and Mahorner[6]).

Many patients request prompt and radical correction of varicose veins to facilitate military or defense appointments or civilian activity. Those with large varicosities have usually been treated in this clinic during the last 27 months by high saphenous ligation, vein stripping, and multiple excision or evulsion of veins, under a general or spinal anesthetic. Pressure bandages have been employed and early activity enforced. This clinical material has facilitated a reëvaluation of the effectiveness and the risk of vein stripping. The operation has been employed in 195 patients. One hundred and two of them, treated 10 to 27 months ago, have been carefully followed and will be reported below. The development of the practice of extensive excision of varicose veins will first be reviewed.

THE DEVELOPMENT OF THE SURGICAL TREATMENT OF VARICOSE VEINS

The operative treatment of varicose veins dates back to the time of Hippocrates,[8] who employed multiple puncture of the veins. Galen, quoted by Aegineta,[9] used a hook to tear out varicosities. Local excision, ligation, incision and cauterization, percutaneous ligation, application of caustics to the skin overlying the veins, injection of various thrombosing solutions, and the application of supporting bandages were all described in the early literature.

Madelung[10] (1884) described an operation for "radical cure" of varicose veins. He completely excised the internal saphenous vein and its associated varicosities through a long incision over the inner aspect of the thigh and leg. This method of treatment was employed in this country in the early twentieth

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century. It was associated with embolism in 7 per cent of the patients, fatal in 0.7 per cent (Bernsten[11]). The 14- to 20-day period of bed rest associated with this operation probably contributed to the high incidence of pulmonary embolism. The percentage of cures was high. Schede[12] (1877) described multiple percutaneous ligation. This method of treatment was found inadequate. Peterson[13] (1893) of Schede's clinic described the procedure which goes by the latter's name. Circular incisions were carried down to the deep fascia on the thighs and legs at several levels. All of the veins encountered were locally excised and ligated. Miller[14] reported a recurrence rate of 67 per cent. A partial or complete Schede incision has since been employed only above ulcers to eradicate venous lakes and communications. Trendelenburg[15] (1891) advocated ligation of the internal saphenous vein in the upper part of the middle third of the thigh and also at times just above or below the internal condyle. Perthes[16] reported a recurrence rate of 22 per cent, and Miller[14] obtained similar results in 41 patients.

Keller[17] (1905) reported a method of extirpating the internal saphenous and other large veins by introducing a wire loop or probe upward through the vessel, securing the upper end of the vessel to it, and then withdrawing the instrument and the invaginated vein. He later combined this method with percutaneous ligatures and obtained satisfactory results.[18] Mayo[19] (1906) described a ring vein "enucleator" which he employed in the treatment of varicose veins. The instrument consisted of a ring of steel, about one-quarter of an inch in diameter, with a long handle. The incompetent saphenous vein was severed high in the thigh, threaded on to the ring enucleator, and stripped down to the knee. At this point the vein was brought out through a small incision and rethreaded through the stripper. The internal saphenous vein may be stripped to the ankle through three to five small incisions. Mayo also employed a partial Schede incision above large ulcers.

Babcock[20] modified Keller's method in 1907, using an "acorn-tipped guide" which was passed down the vein segment, tied to the divided vein, and withdrawn. Friedel,[21] in 1908, described a more radical procedure, the Rindfliech-Friedel operation. The internal saphenous vein was excised in the thigh. An incision down to the deep fascia was then made below the knee and continued as a spiral around the leg down to the foot. The veins encountered were ligated and the wounds were packed open to heal by secondary intention.

The importance of the high saphenous collateral circulation was early recognized and combined with radical surgery. Tavel[22] (1904) advocated high saphenous ligation above these collaterals. He also occasionally injected phenol into the distal vein segment. Homans[23] (1916) reëmphasized the advisability of high ligation and stressed the importance of completely eradicating the internal saphenous vein and its varicose radicles by stripping and excision. The reported results were excellent. Tanner and Fields,[24] (1927) finding multiple ligation or removal of short sections of veins unsatisfactory, advocated removal of the internal and occasionally also the external saphenous

veins from the femoral ring to the ankle. They used a subcutaneous stripper with a small olive tip at one end and a cup at the other. This instrument was passed through the vein segment from below upward. Extraction enucleated the vein without invagination. Satisfactory results were reported. Howard, Jackson, and Mahon,[4] Horgan,[25] and others, advocated stripping from the saphenofemoral junction to the knee and employing injection therapy for the remaining varicosities. Howard, and associates[4], stated that the complete operation of stripping and excision should be carried out when varicose veins were accompanied by incompetency of both saphenous and perforating valves even though the postoperative disability meant temporary loss of time from employment.

This literature review has demonstrated that radical excision of varicose veins coupled with high ligation is effective. Multiple ligations or circular incisions have given poor results. High ligation and radical excision, as recommended by Mayo, Homans, and others, has been employed rarely in recent years because of the associated prolonged hospitalization, the prolonged convalescence, and the risk of emboli or other complications. The extensive literature associated with the practice of high saphenous ligation coupled with injection therapy has been omitted from this review. Complications and loss of time have also occurred following high ligation and injection. The authors have undertaken the present study to reëxamine the risk and the effectiveness of radical excision of varicose veins.

The practice of extensive surgical excision or stripping of large varicose veins has been continued by many surgeons. The results have been in agreement with the literature reports. Injection therapy when employed in large varicosities has produced inflammatory reactions occasionally associated with prolonged disability. Repeated treatments have often been necessary. Many patients are unable or are not willing to return for repeated injections although they require prompt elimination of varicosities for military or economic reasons. Radical removal of varicosities seemed desirable. The authors thought that some of the disadvantages of earlier vein excision and stripping technics might be overcome by supplementing them with elastic pressure bandages and insisting upon early activity. This has now been done in 195 patients. The methods and the results will be reported below.

VEIN STRIPPING TECHNIC

Patients with large incompetent saphenous veins associated with multiple varicosities are selected for operation. The Trendelenburg and the Perthes tests are employed to determine incompetency of the superficial circulation and patency of the deep circulation. Edema, stasis dermatitis, and ulcers if present are treated before operation by supportive therapy and rest. Certain ulcers that fail to heal are compressed preoperatively in the hospital. The course of the veins is carefully marked off with an alcoholic solution of gentian violet immediately before operation. A general or spinal anesthetic is administered. Ultraviolet operating room bactericidal radiation technic is usually

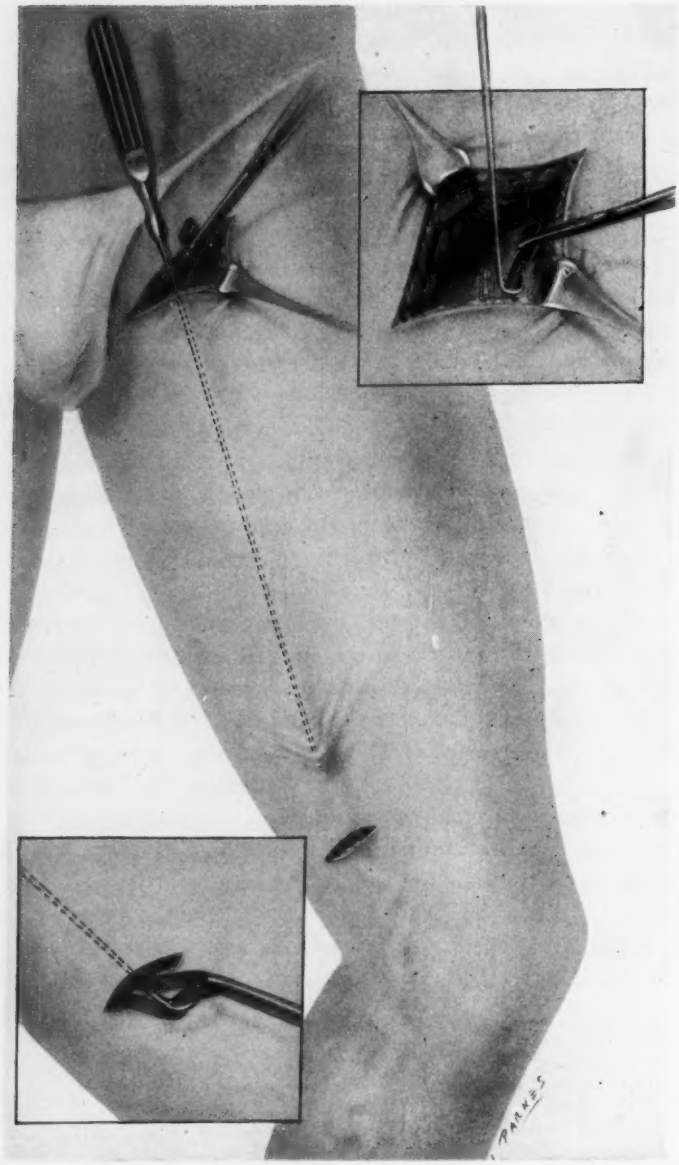

FIG. 1.—The high saphenous ligation with division of all tributaries, stripping of saphenous trunk in the thigh, and location of the distal vein through a small incision that is performed as a preliminary step in the vein stripping operation.

employed. The lower abdomen, groin, and one or both lower extremities are prepared with an antiseptic agent and draped. The internal saphenous vein is exposed through a small oblique incision just below Poupart's ligament, and dissected up to the saphenofemoral junction. All high tributaries of the saphenous vein are divided and ligated or evulsed. The saphenous vein is

FIG. 2

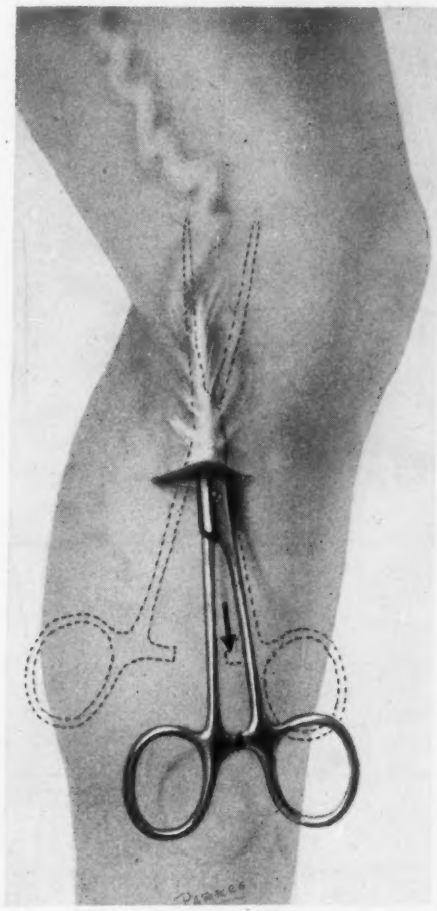

FIG. 3

FIG. 2.—The lower saphenous vein is often located at the ankle near its junction with the medial marginal vein of the foot and stripped upward.
FIG. 3.—Tortuous and friable saphenous veins do not readily strip and may require evulsion.

ligated and divided a few millimeters distal to the saphenofemoral junction. The distal end of the saphenous vein is threaded through a small-size Mayo vein stripper. The vein is then stripped subcutaneously to the knee and brought out through a short incision one or two centimeters in length (Fig. 1). The vein is extracted and rethreaded and stripped downward. If the saphenous vein breaks, the medial marginal vein is located at the ankle and stripped upward (Fig. 2). The entire internal saphenous vein can often be removed

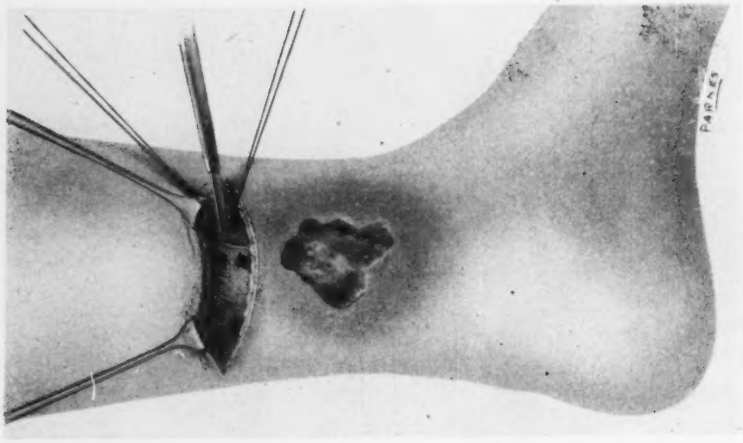

FIG. 5

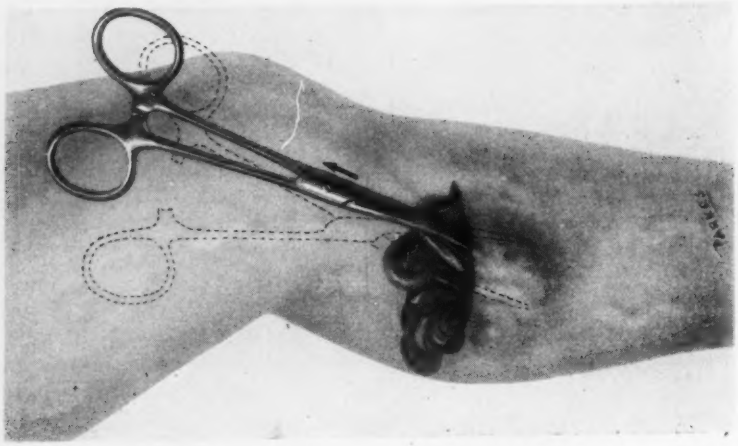

FIG. 4

FIG. 4.—Dissection of localized areas of tortuous varicosities is frequently supplemented by evulsion.
FIG. 5.—A transverse incision down to the deep fascia dividing veins and avoiding cutaneous nerves is often employed above granulating ulcer areas.

through four or five small incisions. Tortuous and friable varicosities often cannot be stripped. They are treated by evulsion (Fig. 3), or by dissection and evulsion (Fig. 4). Bleeding is controlled by pressure applied successively to each operative field. Bilateral varicosities are usually removed simultaneously by two surgical teams. A partial Schede incision (Fig. 5) is frequently carried out above areas of stasis dermatitis or ulcer. Open ulcers are occasionally grafted immediately after the vein operation. Blood clots are carefully expressed, the wounds are sutured and dressed, and the extremities are snugly wrapped with elastic bandages. Active exercise is encouraged in bed after recovery from the anesthetic. The patients are usually urged up and out of bed within 24 hours. Elastic dressings are continued several weeks after operation.

THE EFFECT OF VEIN STRIPPING UPON 17 PATIENTS WITH LARGE INCOMPETENT VARICOSE VEINS, WITHOUT COMPLICATIONS

Seventeen patients with large varicosities but without previous edema, ulcer or thrombophlebitis were treated. The operation was the initial treatment in 13. Two had been treated earlier by injection and two by high saphenous ligation. Enlargement of varicose veins had been noticed two to 27 years, average 11, and had been progressing. The usual complaint was leg fatigue. Examination revealed large, incompetent saphenous veins and varicose tributaries. The deep circulation was patent. Communicating veins were frequently incompetent.

These patients were treated by the operative technic described above. They were hospitalized three to nine days, average five. They returned to full activity between seven and 60 days, average 21. Limited activity began several days after operation. The only complication encountered was moderate temporary swelling of one ankle in one patient. Follow-up examination early revealed successful elimination of all varicosities. Eleven patients later developed small varicosities that required occasional injections. Twelve stated that they were greatly improved, five moderately improved.

THE EFFECT OF VEIN STRIPPING UPON 27 PATIENTS WITH INCOMPETENT VARICOSE SAPHENOUS VEINS ASSOCIATED WITH LOWER LEG, ANKLE, AND FOOT EDEMA

Twenty-seven patients with varicose veins associated with edema of the foot, ankle, and lower leg were treated. The edema was moderate in 19 and severe in eight. These patients gave no history of previous thrombophlebitis. Varicose veins and later gradually progressing edema had been present one to 30 years, average nine. Twenty-one patients had been treated only by elastic support. Five had received injection therapy. One had been treated by high ligation. Examination revealed incompetent varicose superficial veins and patent deep veins.

These patients were hospitalized for vein stripping three to eight days, average six, and returned to full activity between four and 42 days, average 20. Partial activity began in the hospital. There were no serious complica-

tions after operation. Early follow-up examination usually revealed satisfactory elimination of all varicosities. Eleven patients later developed venous enlargements. Seventeen of the 19 patients that had moderate ankle edema now have none. Two have some edema, but less than before operation. Four of the eight that had severe edema now have none. Four have reduction of the degree of edema to less than one-fourth of that present prior to operation. Twenty-one patients reported that they were greatly improved, four moderately improved, and two unchanged.

THE EFFECT OF VEIN STRIPPING UPON 30 PATIENTS WITH INCOMPETENT VARICOSE SAPHENOUS VEINS ASSOCIATED WITH LOWER LEG AND ANKLE ULCERS

Thirty patients with varicose veins associated with stasis ulcers were treated. Varicose veins had been observed two to 48 years, average 15. Leg or ankle ulcers had been present two months to 42 years, average seven and one-half years. All patients received treatment before vein stripping, varying from bed rest and support through boots, injections, and in five saphenous ligation. Twenty-two also had definite lower leg and ankle edema. Examination revealed incompetent saphenous veins and patent deep veins. Nine ulcers were open at the time of vein stripping. These were skin-grafted immediately after operation in eight patients and before in one. Postoperative boot or elastic support was employed for several months.

FIG. 6. — The usual degree of enlargement of incompetent superficial varicose veins treated in 17 patients by vein stripping and followed for the late effect of operation.

The period of hospitalization ranged from three to 53 days, average eight, and of partial disability from seven to 120 days, average 36. Early postoperative examination usually revealed that all demonstrable varicosities were eliminated. Thirteen patients later developed small varicose veins. All ulcers initially healed. Twenty-four have remained healed since elastic or boot support was discontinued. Six have recurred and required further treatment. Some edema remained in nine of the 22 patients that had edema before operation. Twenty-two patients stated that they were greatly improved, six moderately improved, and two unchanged.

THE EFFECT OF VEIN STRIPPING UPON 22 PATIENTS WITH A PREVIOUS DEEP OBSTRUCTING THROMBOPHLEBITIS

Twenty-two patients that gave a history of an old deep thrombophlebitis beginning with marked inflammatory reaction and edema of the entire leg were treated. The thrombophlebitis was related to pregnancy in nine, abdominal operation in six, trauma in two, typhoid in two, Rocky Mountain Spotted Fever in one, pneumonia in one, and an unknown cause in one. The onset of thrombophlebitis preceded the vein stripping by three to 40 years,

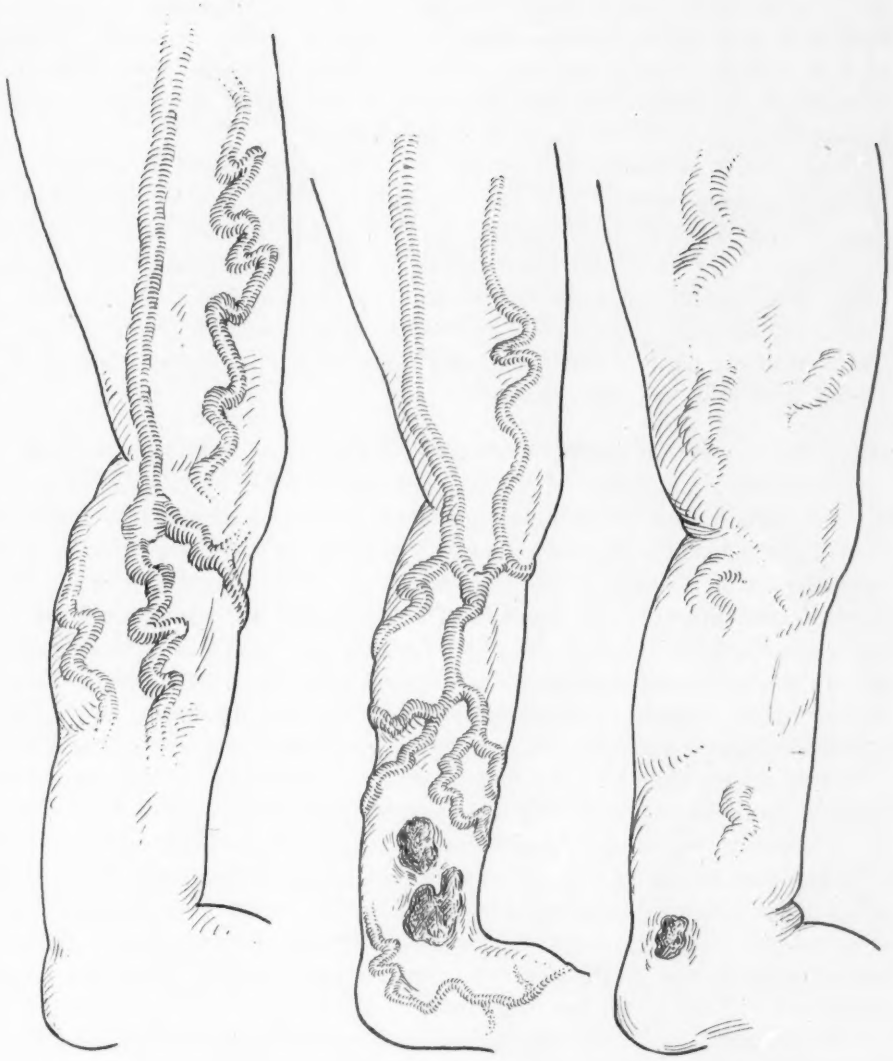

FIG. 7 FIG. 8 FIG. 9

FIG. 7.—The usual degree of enlargement of incompetent varicose veins and edema treated in 27 patients by vein stripping.

FIG. 8.—The usual degree of enlargement of incompetent varicose veins and the usual type of ulcer present in 30 patients treated by vein stripping.

FIG. 9.—The usual degree of leg edema present at the time of vein stripping in 22 patients that had a previous deep obstructing thrombophlebitis.

average 16. Two patients had noticed varicose veins before the thrombophlebitis. The remainder developed varicose veins and complications late after the thrombophlebitis. All patients had leg edema. Sixteen had had ulcers eight months to 30 years, average 10 years. All patients had been treated by bed rest, supportive boots, or injection therapy, and seven had had in addition high saphenous ligation. The tourniquet tests revealed incompetent superficial veins and patent or probably patent deep veins. Nine patients had open ulcers at the time of operation.

The period of hospitalization for vein stripping ranged from five to 19 days, average eight. The period preceding return to regular activity ranged from five to 90 days, average 37. Ten of the 16 ulcers have remained healed since operation. Six have recurred in spite of continued conservative care. The leg edema has disappeared in 13, decreased in five, and remained unchanged in four. Small new varicosities have developed in 13 patients. Thirteen of the patients stated that they were greatly improved, eight moderately improved, and one unchanged.

THE EFFECT OF VEIN STRIPPING UPON SIX PATIENTS WITH LARGE INCOMPETENT VARICOSE SAPHENOUS VEINS AND MISCELLANEOUS COMPLICATIONS

Two patients entered the hospital with bilateral large incompetent varicose veins present many years and complicated during the preceding week by the development of a clot or phlebothrombosis, six or seven inches long, in the dilated saphenous trunk of one leg. This developed just above the knee in one patient and just below in the other. Inflammatory induration was present about the clot and lower leg edema had begun. Deep veins were patent. Both patients were treated by bilateral high ligation and vein stripping. The clotted areas were partially stripped, partially dissected, and partially evulsed. The patients were out of bed within 24 hours. The areas of excision of the phlebothrombosis healed quickly. Lower leg edema did not recur.

One patient was treated for varicose veins that had developed in edematous ulcerated legs during 25 years of intermittent and varied treatment of a severe burn of both legs. Numerous skin grafts applied to the several ulcers had disappeared following return to activity. Bilateral vein stripping followed immediately by skin grafting effected complete early healing. One year later the ulcers and the edema had recurred.

Three patients with definite familial and congenital edema of the lower legs associated with enlarged incompetent varicose superficial and patent deep veins were treated by stripping. The edema, late after operation, was unchanged in one patient, somewhat increased in one, and improved in one. New large varicosities developed within a year in each patient.

SUMMARY

One hundred and ninety-five patients with large incompetent leg varicosities have been treated during the last 27 months employing high ligation, vein stripping, excision and evulsion of veins, pressure bandages, and early ac-

tivity. This procedure was applied simultaneously to both legs in 147 patients, to one leg only in 43, and to one leg with high saphenous ligation of the other in five. There has been no operative and no late mortality from the procedure or from complications of varicose veins. Clinically recognizable pulmonary embolism did not occur.

A few patients developed surgical complications. One obese patient had a cardiac decompensation and oliguria that responded to treatment within one week. One had a large inguinal incisional hematoma that subsided spontaneously. Five patients among 25 operated upon with open ulcers and others with some degree of stasis dermatitis developed subcutaneous localized abscesses that required treatment. The transverse Schede incision, when employed, frequently opened and healed by secondary intention. Occasional patients developed small hematomas in the subcutaneous defects produced by the stripping. These absorbed spontaneously.

One hundred and two of the 195 patients treated between 10 and 27 months ago have been carefully followed and reëxamined. They have been described above in five separate groups. In all groups demonstrable varicosities have been eliminated by the operation except for occasional overlooked variocose tributaries. Small new varicosities appeared later in 51 of the 102 patients. A few of these became large enough to require treatment by limited surgical excision or by injection. Lower leg, ankle, and foot edema was present in 77 patients. Late examination revealed no edema in 49, improvement in 21, no change in 6, and increased edema in 1. Lower leg or ankle ulcers present in 47 patients responded to preoperative treatment in 28 and were open and skin grafted at the time of operation in 19. Thirty-four have remained healed since operation and 13 have recurred although reduced in size. Seventy-one patients stated that they were greatly improved, 24 that they were moderately improved, and 7 that they were unimproved.

Recently the vein stripping procedure has been extended to include patients with less advanced pathologic change. The period of hospitalization in this group was 3 or 4 days and the period of limited activity 7 to 10 days. The results were uniformly satisfactory.

CONCLUSIONS

High saphenous ligation, vein stripping, and either excision or evulsion of veins combined with pressure bandages and early activity has proved effective in the treatment of a group of patients with advanced pathologic change associated with large varicose veins. It has, in the opinion of the authors, been more effective than ligation and injection therapy used earlier in patients with similarly advanced pathologic change. Although the operation has exposed large areas of skin and was often carried out in the presence of granulating open ulcers, it has been performed with a low rate of infection. Pressure bandages and early activity may account for the absence of pulmonary embolism or deep vein thrombosis. The appearance of new small

varicosities in one-half of the patients within the short period of observation covered in this report suggest that some defect of the remaining veins or abnormality of circulation must exist that is not entirely corrected.

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DISCUSSION:—DR. HOWARD MAHORNER, New Orleans, La.: I want to congratulate Doctor Grimson on his results. He has certainly carefully tabulated and evaluated these and no one could expect better results. I cannot, however, agree that stripping is very often indicated. It is generally known that high ligation alone is not the entire treatment for varicose veins, and that multiple ligations and segmental excisions are frequently indicated. I think the type of operation chosen must be adapted to the case in question and one should not expect too much in the absolute prevention of any evidence of recurrence such as mild ectasias. Doctor Grimson found some mild evidence of recurrence in an appreciable percentage of their patients. This simply emphasizes the fact that, by surgery, one can cure the varicose veins but not the tendency to varicose veins. Moreover, no type of operation establishes the normal physiology.

Some of my friends have spoken to me favorably of stripping, and I do not disagree that it might be an advantage in certain cases. However, I prefer to divide the operations indicated into five types, depending on the degree of varicosity and the complications (slide). In the first group, sometimes with large varicosities when the retrograde flow is only through the saphenous, a single ligation is all that is necessary. If the patient is past middle age, he will not develop varicose veins again; if he is younger, he may. If there is retrograde flow from the deep to the superficial veins below the main opening of the saphenous, an additional ligation above the knee is necessary. In some instances, if the varices are large, excision of segments is indicated, sometimes even on the outer side of the thigh. When varicose veins are extremely severe and retrograde flow occurs at various levels in the leg, these leaks may be determined by the comparative tourniquet (Mahorner-Ochsner) test. In such cases one should attempt to stop such abnormal flow; and it is not feasible to tie off each little communicating vein. Just remove the segment into which they are leaking. It is sometimes essential to cut out scarred areas in the region of the ankle and regraft that particular part.

I am sure stripping of the veins should never be forgotten because it has merit in some cases, but the point I wish to make is that no one operation should be used and adapted to all the cases one encounters.

DR. H. M. SCHIEBEL, Durham, N. C.: I would like to say a few words about our work along this line. I have been much interested in varicose veins for about 13 years, since I was put in the Vein Clinic at Baltimore some years ago and had to dress ulcers all morning time after time. We became awfully tired of this, and I am sure every one here has had about the same experience. From that time on I have been consistently interested in something that would cure these people. I do not think we wish to say, however, that we have found something which is completely curing these patients. We have used a series of different methods in trying to cure them. We have tried high ligation, multiple ligations, removal of segments, and still do these procedures on patients when we think these operations will eradicate the pathologic condition. We do feel, however, that the old operation of stripping these veins, which was almost completely discarded, should be given more attention in treating some people who are really bad varicose vein patients.

We have learned something else from this procedure. There have been many theories about the formation of varicose veins and we do not know the cause, but we have learned one thing by actually examining the long segments removed. We have seen that there is a remarkable absence of the normal number of valves in these veins. Our pathology department reports that these patients have from one-fourth to one-sixth the normal number of valves, and this may be something added to our knowledge of these patients. In our follow-up we notice that we see little spots appearing here and there, more often in the young than in the old. On the other hand the results are better in the young with severe varicose veins than in the old patients, for the reason that there has been less edema and, therefore, little or no pathologic change in the skin and subcutaneous tissue.

With regard to hospitalization, we have frequently heard the comment by the proponents of simple ligation and injection that it is not necessary to hospitalize their patients. We want to say that it has not been necessary to hospitalize ours very long. Some of our house officers and nurses have had veins treated by this method and they are back working early. One nurse went back in four days; she did not work full time, but did some of her work and did not wish to stay off duty. She was not uncomfortable, and she wanted to move about.

Dr. Keith S. Grimson, Durham, N. C. (closing): The comments of Doctor Mahorner and the illustrations of his technics for surgical excision of varicose veins are welcome. Large localized varicosities may well require excision. Vein stripping and vein evulsion as employed in our study is a rough rather than a precise form of surgery. It has, however, facilitated elimination of extensive varicosities not easily accessible for nice dissection. Injection therapy used earlier for large varicosities was associated with foreign body reactions and other complications more troublesome than those associated with vein stripping.

QUADRICEPSPLASTY*

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FROM THE WALTER REED GENERAL HOSPITAL, ARMY MEDICAL CENTER, WASHINGTON, D. C.

THE RESIDUAL DISABILITY following any severe injury to an extremity is just as often due to loss of function of the soft parts as to malunion, nonunion, or infection of the bones. Malunion can usually be prevented and is not difficult to correct. Nonunion can be overcome by bone grafts even when there has been considerable loss of bone. Infection can be prevented or eliminated by sulpha drugs and penicillin provided sound surgical procedures

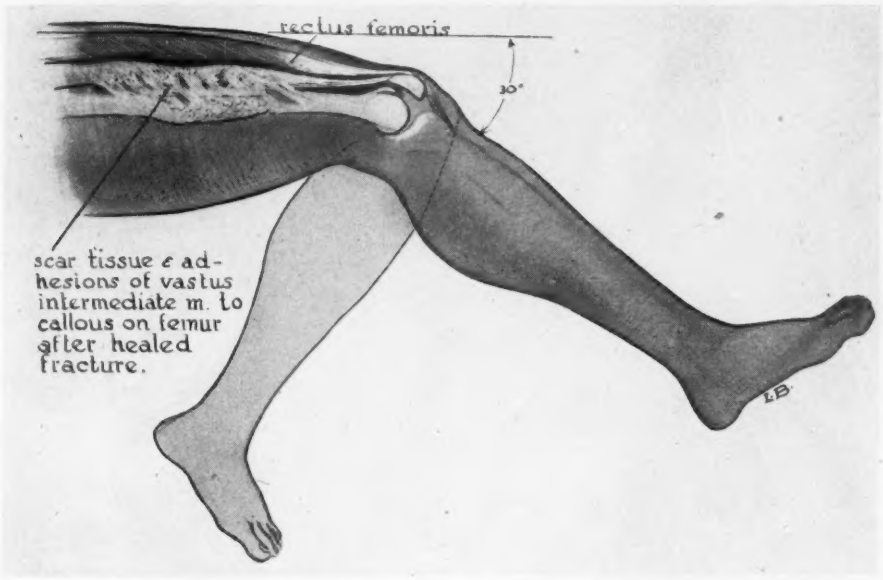


FIG. 1.—Drawing illustrating adhesions between quadriceps and adjoining muscle.

have not been neglected. Soft-part injuries heal rapidly as compared to fractures but complete restoration of normal function is rarely attained. Plastic surgery has accomplished wonders in correcting deformities due to extensive skin loss but when tissues with very specialized functions are replaced or surrounded by scar tissue, considerable loss of function is inevitable.

Reducing scar formation to a minimum is the secret of success in nerve suture and nerve grafting. Restoration of function in a repaired or transplanted tendon can never be obtained if there is scarring between the tendon and the surrounding structures.

* Read before the Fifty-sixth Annual Session of the Southern Surgical Association, December 5–7, 1944, Hot Springs, Va.

FIG. 2

FIG. 3

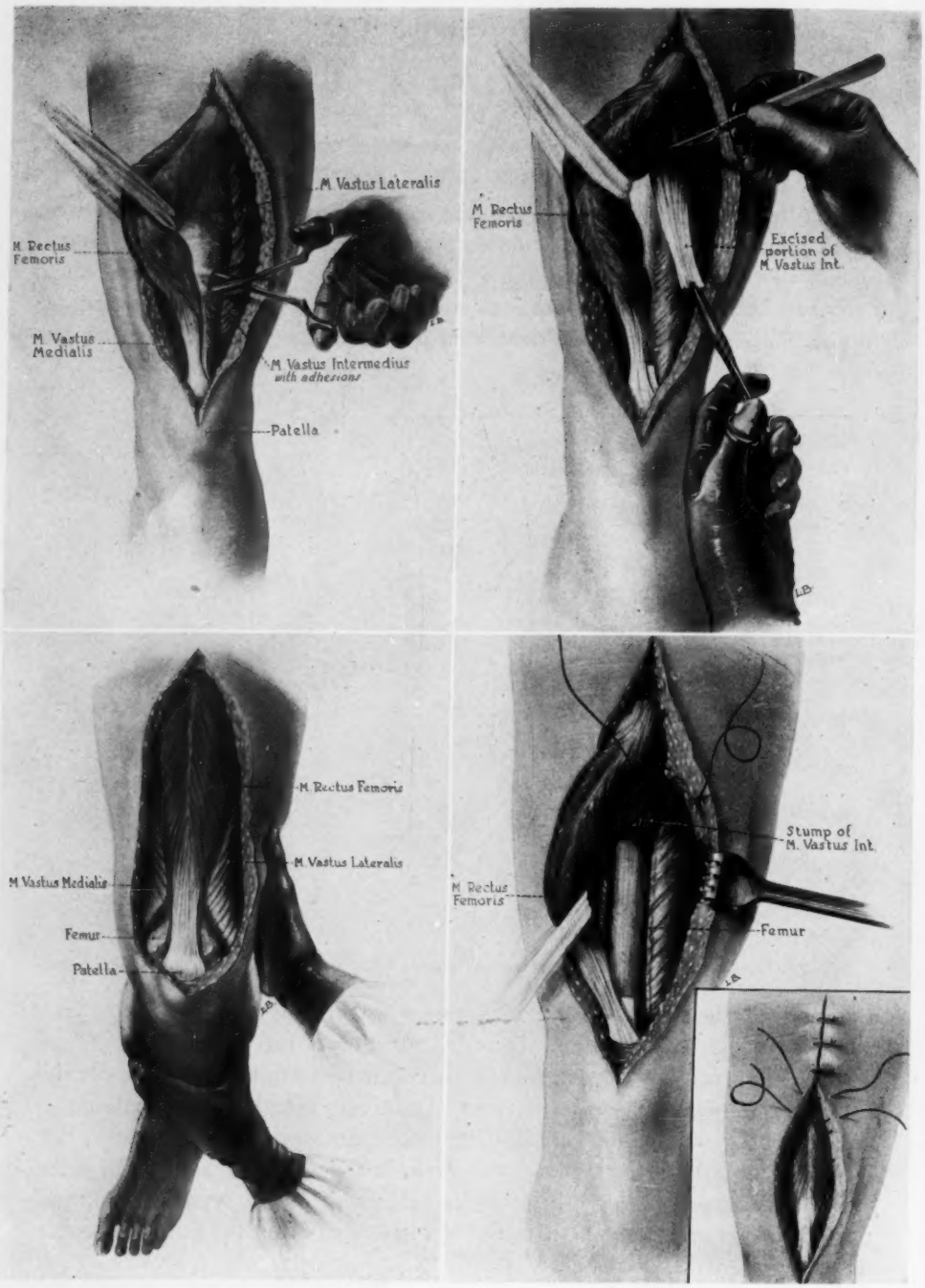


FIG. 4

FIG. 5

FIG. 2, 3, 4, 5.—Illustrating the steps in the operative procedure.

When one considers that the fundamental characteristic of a muscle is its power to enlarge in its transverse diameter while it shortens in length, it is obvious that any scarring or fibrosis either in or around a muscle will so

FIG. 6.—Illustrating degree of flexion obtained.

FIG. 7.—Illustrating amount of extension.

effectively reduce its activity that the range of motion in the joints controlled by the muscle will be drastically curtailed or even eliminated. The excision of the scarred portion of a muscle or the isolation of a normal muscle from

surrounding scar tissue will often result in marked improvement in both active and passive motion of the joint controlled by the muscle. The principle of excision or isolation of scar tissue can be used in any part of the body. The motion picture which follows shows how it can be applied to the extensor mechanism of the thigh.

The shaft of the femur is almost completely surrounded by the vastus lateralis, vastus medialis, and vastus intermedius. Any injury to the thigh, especially a compound fracture due to a missile injury, will cause scarring and fibrosis in one or more of these muscle bellies. The loss of extensibility of any of these muscles will effectively limit knee motion by anchoring the patella to the femur. Manipulation in an attempt to improve flexion is very apt to result in fracture of the patella. The rectus femoris muscle is more superficial than the rest of the quadriceps and often escapes injury. It is longer than the other components of the quadriceps mechanism and can be dissected away from them without destroying its nerve and blood supply.

In the operative procedure to be shown the scarred vastus intermedius is excised. The knee is then flexed to 90 degrees, or beyond, *without lengthening* the rectus femoris muscle. If either of the remaining vastus muscles is badly scarred it is isolated from the rectus femoris muscle by making a new intermuscular septum of soft tissue. The intact rectus femoris permits *early active motion* and is the reason why most of these patients have regained full active extension.

Nineteen patients have been operated upon with very satisfactory results in all, as far as increase of flexion is concerned. Two of these patients with extensive scarring of all components of the quadriceps muscle, including the rectus femoris, have not regained full active extension. This could scarcely have been expected.

This principle of radical excision of scarred muscle and isolation of active muscle from scar tissue has also been applied to the shoulder, elbow, wrist, and calf.

CONCLUSIONS

1. Excision of scar tissue from a muscle increases the extensibility and contractility of the remaining muscle.

2. The interposition of normal tissue between normal muscle and scar tissue allows the muscle to function more effectively.

3. The application of these two principles to thigh injuries results in remarkable improvement in knee function.

DISCUSSION.—DR. GEORGE E. BENNETT, Baltimore, Md.: Of course you all understand it is a great pleasure for me to open the discussion on this paper. Lengthening the quadriceps is one of my babies. I did my first case in June, 1917—about 27 years ago. The operation was simply the application of an old surgical principle in a new location. Colonel Thompson's quadricepsplasty is again the application of an old surgical principle. He selects a type of injury of the femur and muscles which results in tying down of the vastus intermedius and by removal of the scarred area the leg can be flexed to approximately 90 degrees without disturbing the rectus muscle and speeds recovery to

full extension of the knee joint, which has been one of the drawbacks in quadriceps lengthening. I have made some modifications in the original technic described and practiced in selected cases. It must be borne in mind, however, that Colonel Thompson's tenoplasty is not applicable to muscle shortening in the lower third or upper third of the femur. I should like to congratulate him on this splendid paper.

DR. PAUL B. MAGNUSON, Chicago, Ill.: This paper of Colonel Thompson's, with presentation of his method of lengthening the quadriceps, has been extremely interesting. It would be informative if we could go into the causes which bring on the necessity for the operation described by him. I cannot resist saying that incision through the middle of the quadriceps is the cause in most cases and that in most instances the operation should never have been necessary.

I could not help noticing that the manipulation was rather aggressively performed, but I know that Colonel Thompson is very careful about this manipulation, and that it is done slowly under very well-controlled force. If it is not, there is serious danger of fracturing the femur just above the condyles, especially if the leg has been non-weight-bearing for some time and there exists the atrophy of disuse. Overzealous manipulation is to be avoided.

I think Colonel Thompson's adaptation of Doctor Bennett's original procedure is well thought out and well executed.

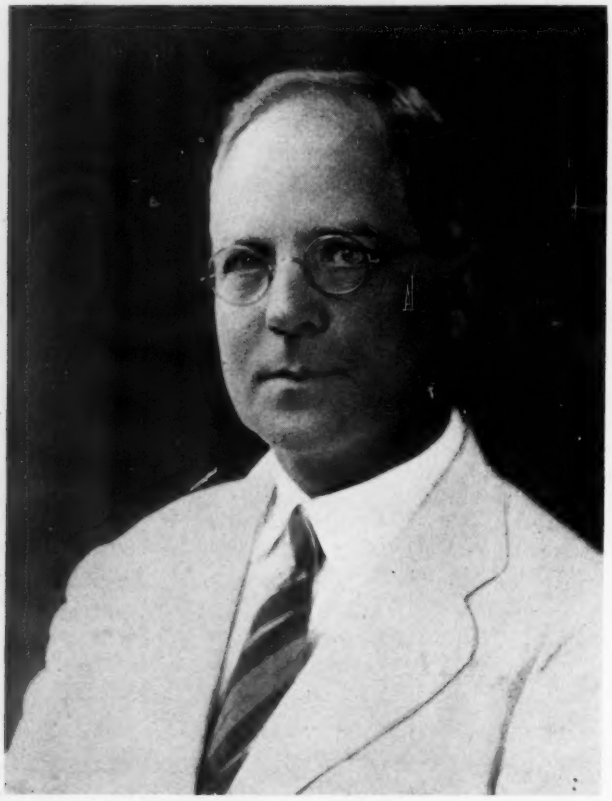
LT. COL. T. C. THOMPSON, Washington, D. C. (closing): I wish to thank Doctor Bennett and Doctor Magnuson for their remarks. I do not claim any originality for this procedure, but the fact that part of the muscle can be left intact does help a great deal in early restoration of function. So far as the cause of a stiff knee is concerned, I think there will be some limitation of knee motion following a fracture of the femur no matter what form of treatment has been used. In my experience, there is more stiffness following multiple pin fixation than any other type of treatment. It is practically impossible to put a pin into the femur without going through the quadriceps. Although these patients do move their knees, they do not move through a full range. There is always some fibrosis and consequent restriction of motion. Most of the cases in these series have resulted from severe compound fractures, usually with extensive soft tissue injury. Some have had loss of muscle, draining sinuses, and scars, which have required a number of operations to obtain healing. In such cases one must do what he can with what is left. We could go on and on about the correct treatment of fracture of the femur, but that is not our thesis today.

MEMOIRS

HERMANN BERTRAM GESSNER

1872—1944

FOREWORD: I deem it particularly fitting that I should pay a tribute to the memory of Dr. Hermann Bertram Gessner, who was first my intern, then my assistant, later my colleague and for fifty years my loyal friend.



Doctor Gessner's professional career began as an intern at the Charity Hospital of New Orleans in the fall of 1895, when he was assigned to my service in the surgical division of the Tulane University, to which I had been appointed chief that year, as the newly elected Professor of Surgery. The professional relations there established continued as an uninterrupted and warm friendship for over half a century when his untimely death on August 31, 1944, severed the link that for so many years had united our interests in the same tasks, whether in the clinic, at the bedside, in the classroom or in the operating theater. In these relations, the official differences in rank and age as between Chief and Intern, Professor and Student, Senior and Junior,

played no part, because lines of demarcation were never visible in an association characterized by mutual affection and respect.*

* * *

HERMANN BERTRAM GESSNER was born in New Orleans on February 19, 1872. His father, George Gessner, born in Bavaria, came to America in 1853. As a student at the University of Würzburg, he participated in the uprising for a Constitution that took place in Germany in 1848. From 1853 to 1907, Professor Gessner taught the classics and German in New Orleans, with the exception of his period of service in the Confederate States Army with the Washington Artillery, from 1862–1865. While his teaching was principally in the form of coaching private pupils, he taught also in several schools, including Tulane University which, in 1906, gave him the degree of LL.D. Doctor Gessner's mother, née Josephine Nicks, came to New Orleans from her native city of Bremen in 1850, when she entered the school of the Ursuline Convent.

After attending various private schools, Doctor Gessner entered the High School of the University of Louisiana, which was soon to become the Tulane University. In 1889, he received the degree of A.B. "with distinction." In 1891, that of A.M. Also, in 1889, he shared the Judah Touro Medal for Greek with another classmate. During this period, he became a charter member of the Louisiana Alpha Chapter of Phi Delta Theta. Later, he was elected a member of Phi Beta Kappa. After two years in the Medical School of Tulane, he entered the Charity Hospital as resident student and ambulance surgeon, one of six successful aspirants out of forty in the annual competitive examinations.

As an undergraduate intern, he showed so much efficiency that he was appointed "Chief of Clinic" (equivalent, at present, to clinical assistant) in my service at his graduation 1895. In this position, Gessner soon developed the qualities of system, method, and precision which had distinguished his father, the famous Professor Gessner, as a teacher of languages in New Orleans. In fact, Hermann, the son, was a remarkable example of the transmission of hereditary traits and aptitudes, for, even as a school boy, he had already acquired a very correct knowledge of German from his father and almost as good a knowledge of French, from his mother, who, though a native German, had been educated in French at the Ursuline Convent in New Orleans. Besides an unusual linguistic memory, Gessner had been thoroughly drilled in the principles of language and the fundamentals of grammar by his father, a rigid disciplinarian in the study of basic philologic principles, as became a professor brought up in a German university. With grammar as a key, Gessner acquired Spanish and the rudiments of the

* Doctor Gessner was the first in a long list of young men who gave me the benefit of their service, their loyalty, their talent and the vigor of their youth in helping me to discharge my mission as a teacher of surgery during the 32 years of my professorship at Tulane. For all these, living and dead, I retain ever-green and grateful memories.

Romance languages with ease; an acquisition which in later years served him in good stead by developing a clientele among the Latin-American residents of this city. His philologic aptitudes were also a great help to him by his mastery of German, which had become so essential to Medicine at the time of his graduation. The Germanophile wave which had begun after the Franco-Prussian war (1870–71) had gained great momentum during the Bismarckian period, sweeping over the medical literature and thought of this country and centralizing all postgraduate medical education in Vienna and Berlin, the dual Mecca of all medical graduates who could afford to travel. During this period, German was at a premium and German teachers and translators were in demand. No scientific article seemed complete without a reference to the current German literature. Every young writer who aspired to scientific recognition had to show his proficiency in research by his fluent citations of the Zentralblatts, Jährsberichts, Beiträges, Wochenschrifts, Archives, Ergebnises, Sammlungs and the what-not of the elaborate catalogue of the classified periodical German literature. In fact, no man was worth talking to on any scientific subject if he could not quote German authority. Those who could not were antiquated or out of date. All this was before 1914–1918 when the Americans learned that they did not have to cross the ocean to worship in Aesculapian shrines. From this viewpoint alone, it is evident that Gessner's thorough mastery of German was of incalculable advantage to him; not only by adding considerably to his academic height among his scientific friends but by notably increasing the circle of his clientele.

Despite his attainments in the humanities, Gessner never obtruded his superior knowledge and culture except on rare occasions when some obnoxious bombast in the class needed a fine needle-prick to deflate his bulk; a few murmured words quoted from Latin or Greek by Gessner sufficed to collapse the balloon.

He was elected demonstrator in the laboratory of operative surgery in succession of Dr. W. S. Bickham, the very capable first incumbent in this department, whom Gessner had assisted for two sessions. From demonstrator he was soon promoted to the professorship of Operative Surgery, serving in this capacity from 1900 to 1907, when he was elected professor of Clinical Surgery, which he held until September 1, 1936, when compelled to resign by ill health. He was my senior assistant in the operating room at Charity Hospital and at Touro Infirmary from 1895 to 1905, after which he became senior associate surgeon on the visiting staff at the Touro Infirmary—a position which he retained until 1936. In 1889, he took a very active interest in the teaching of oral surgery at the New Orleans College of Dentistry, later the Dental Department of Tulane University, which he had largely helped to organize.

In 1905, he spent several months studying the histology of tumors with Doctor Bloodgood at Johns Hopkins Hospital. In 1907, he studied in London, chiefly in the clinics of the West London Hospital.

Despite the great demands made on his time by his teaching and hospital

duties and rising practice, he contributed many valuable papers which were largely read at the proceedings of the local parish, state and regional societies. These were largely based on the observations and experiences that he shared with me as my senior assistant at the Charity Hospital and at Touro Infirmary. Quite apart, and in addition to, the regular routine of appendicectomies, hernioplasties, gallbladder and stomach operations, he took special interest in the treatment of aneurysms, in which he became an early pioneer by following closely in the wake of my operations in which he participated as my assistant. In this way, he became an expert in the technic, as shown by his paper entitled, "My Experiences in the Matas Operation of Endo-aneurysmorrhaphy" (New Orleans Med. & Surg. Jour., **67**, 598, January, 1915) in which he reported seven operations for aneurysms of the lower extremities, including three cases of arteriovenous fistula, without a death or disability attributable to the operation. He was the first surgeon in Louisiana to repeat my experience and results in endo-aneurysmorrhaphy for arterial aneurysms (June 20, 1904) and in the cure of arteriovenous fistula (May 30, 1908) by the Matas-Bickham transvenous technic, as described in the ANNALS OF SURGERY, May, 1904.

His "Experience with the Matas-Allen Aluminum Band as a Test of the Collateral Circulation in the Circle of Willis" in dealing with the ligation or occlusion of the common and internal carotids (Southern Med. Jour., **5**, 307–31, June, 1912) was a very conclusive demonstration of the practical value of the band in giving timely notice of acute cerebral ischemia following the occlusion of the artery. This paper and his report of cases of elephantiasis and lymphedema as a supplement to my first paper on the kondoleon operation as applied to nonfilarial elephantiasis (1913) were the outcome of our collaboration at the Touro and at Charity Hospital. Apart from this, the subjects of his papers were largely suggested by his observations and reflections on the diseases most frequent in our southern subtropical environment as exhibited in our large Negro services at the Charity Hospital, namely, abscess of the liver, elephantiasis nostras, ainhun, actinomycosis, and the problems of surgical tuberculosis, cancer, tetanus, traumatisms of the bones and joints, gunshot wounds of the heart, chest and abdomen. His teachings as demonstrator of operative surgery also led to his special attention to the methods of local and regional anesthesia which were such a distinct and absorbing feature of our clinic in the first three decades after Koller's discovery of cocaine (1884), transfusion, methods of amputation, arthroplasties, plating of fractures and skin grafting, which are all reflected in his "Laboratory Guide," published in 1906. He also did experimental work on the circulation of the testis in connection with cryptorchidism and the operations for its correction (1912, 1913). It is remarkable that with his great ability for bibliographic research, the list of his publications is not more extensive, amounting to about eighty-five papers and addresses, which appear in the transactions of the local, state and regional societies of which he was a member. They are almost all contained in the official journals, the New Orleans Medical and Surgical

Journal, the J. A. M. A., the ANNALS OF SURGERY, Southern Med. Jour., and others.* Gessner's aim in writing was very much as his oral teaching—chiefly directed at lucidity, brevity and correctness, without display of ornamental bibliographic erudition. This anomaly in a man of his scholarly taste is accounted for, partly, by the fact that bibliographic research was very expensive in New Orleans in the earlier years of his practice. The local library was very scant in texts and periodicals (the German especially) for a young doctor struggling for a living and caring for the needs of a growing family. In fact, to do any work of consequence required frequent visits to the Surgeon General's Library at Washington, which was time-consuming as well as expensive—all of which accounts for the general penury in the medical literature of the South from the end of the Civil War to the first decade of the present century. In addition to these obstacles in Gessner's case was the consciousness of his cardiac disability at a time when he could have contributed much more of his mature learning and experience.

As a surgeon, Gessner's excellent anatomical and technical foundation made him accurate, deliberate and safe; bold when necessary, but not adventurous. Always keenly sensitive of his responsibility to his patients and, as an honest teacher to his students, he gave much time to the preparation and after-care of his patients. Naturally reserved and serious-minded, he never indulged in levity or coarse remarks; he gave dignity to the operating room and to surgery without pretentious solemnity. He was uniformly kind and gentle to all his patients; the Negroes, who contributed the bulk of his surgery at the Charity Hospital, always rejoiced when he made his rounds. He had the human touch and earned loyal friendships from the humbler ranks of life. As a teacher, simplicity, method, clarity, precision gave special value and impressiveness to his lectures and demonstrations as well as to his discussions at the meetings of the medical societies.

Activity in medical organization characterized Doctor Gessner's professional life from the first. He was a member of the Orleans Parish Medical Society (President, 1902), Louisiana State Medical Society (President, 1930–'31), Southern Medical Association, Fellow of A.C.S. and for twenty-seven years a Fellow of the Southern Surgical Association. All of these societies particularly of the City and State, show in their proceedings distinct evidence of his animated and unfailing participation in their work Deeply interested in the Charity Hospital and in the efforts of the Visiting Staff to secure recognition in the management of the professional side of the Institution, he was Chairman of the Conference Committee of the Visiting Staff from 1913–1915.

He served as an acting Assistant Surgeon, U. S. Army, in the Spanish-American War of 1898, and as First Lieutenant in the Reserve Medical Corps of the U. S. Army in 1916, on the Mexican Border. There were also two temporary Service connections with the U. S. Health Service in 1897 and

* A complete chronologic bibliography, with copies of reports, are available at the Rudolph Matas Library Medical School, Tulane University of Louisiana.

in the historic antimosquito campaign of 1905 which put an end to all yellow fever visitations in New Orleans.

Ever conscious of his duties as a citizen, he unfailingly qualified as a voter by registration and payments of poll tax; he cast his vote in every contested election; strong in his convictions, always in the lead as a supporter of good government and of every civic and cultural movement that tended to advance the welfare of the community.

Long-time a member of the Unitarian Church, he was a devoted worker in its fold and held practically all the offices, including the presidency, that the congregation could give to its communicants. Deeply religious in a reverent, cosmic sense, and a liberal and humanist, as said by his Minister at his obsequies, "There was no dogmatism in his religion; instead, there was tolerance and mercy and tenderness and justice."

Cardiac disease, the tragedy of his life, came relatively early at the age of 57, in 1929, to influence his career by imposing a disability which ultimately robbed him of a full decade of activity in his profession and of the most useful years of service to the community.

A ruptured appendix and peritonitis, complicated by a widely diffused thrombophlebitis came in 1935 to add new burdens to the crippling effect of his previous cardiac disability, compelling him to retire altogether from practice and resign all his professional appointments. In 1936, a year after this event, the Faculty conferred on him the title of Emeritus and the Charity Hospital and Touro Infirmary that of Consulting Surgeon. Despite his disabilities and compulsory rest during the ten years of his retirement, he kept in touch with the literature of the profession and especially its all-absorbing social, economic and legislative problems. He found great recreation in the company of his friends and those who assembled regularly at the Round Table Club, of which he was president (1937–38), where he promoted and shared the spirit of good fellowship to the very end.

Another side of his life was known only to his close friends. He loved the outdoor life and enjoyed the opportunities that his retirement gave him to indulge in fishing—his favorite sport—which had been denied him in the busy days of his practice. The folklore of the bayous and of the swamps which he gathered on his fishing trips interested him, and the comrades who accompanied him brought back stories of "the grand old man who would sit listening to the swish of the water and talk about the stars."

His illness, which had been fairly well tolerated during the years of his retirement, grew rapidly worse in the last few months before his death, culminating in violent attacks of angina pectoris, which ended fatally in the afternoon of August 31, 1944. At the autopsy, which was held in accord with his long expressed wish to his wife, the presence of a large organized, partially calcified mural thrombus was revealed in the left ventricle, which partly filled the ventricular space. The thrombus had followed a cardiac infarct in the ventricular wall at the time, no doubt, when he felt the first pain of angina fifteen years before his death. There were also evidences

of coronary disease and of other secondary visceral lesions, but in the opinion of his physicians and pathologists (Drs. Randolph Lyons, Lawson, and Friedrichs), who performed the autopsy, the thrombus was the prime cause of his death. His tolerance of this remarkable concretion for so many years was in itself a valuable contribution to the pathology and prognosis of heart disease; it fully justified his insistence on a postmortem investigation. Also, as evidence of Doctor Gessner's calm and deliberate contemplation of his approaching end was his request that his remains be cremated and his ashes strewn on the ground where his father had been buried thirty-seven years before him.

Thus ended Dr. Hermann Bertram Gessner, a fine, intellectual and honored citizen, an excellent surgeon and a teacher of genuine distinction in his art, a scholar of high attainments whose merit will always be remembered by the thousands of the students and others who profited by his knowledge and example during the forty years that he was a teacher in the schools. Personally, as I knew him, he was the incarnation of honesty, absolute integrity. Incapable of insincerity or of shallow snobbish pretensions, always affable, approachable and self-contained but never exuberant; he was very firm in his convictions which were not easily displaced once he had arrived at them. He possessed a quiet dignity without austerity, which commanded confidence and respect of his colleagues and laymen alike. It has been well said that Doctor Gessner's personal friends were as numerous as his acquaintances, and his death has brought sorrow to many. A devoted husband and affectionate father, he was particularly zealous to see that his children were given the best educational opportunities. As told by his oldest daughter, "he accepted the older pattern of discipline, but mellowed through the years and was more indulgent to his grandchildren than as a busy Surgeon he had had time to be with his children."

He is mourned by his wife, née Jessie Hayes, of Lake Charles, Louisiana, and four children, Leonard E., Josephine H. (Mrs. Austin Ferguson), Barbara J., and Commander Edward H. Gessner, U.S.N.R., whose distinguished service in Normandy Beach, Cherbourg, Newfoundland and other Battle Fronts, have won him high distinction as a brave and resourceful Commander in the Naval Service of the Nation.

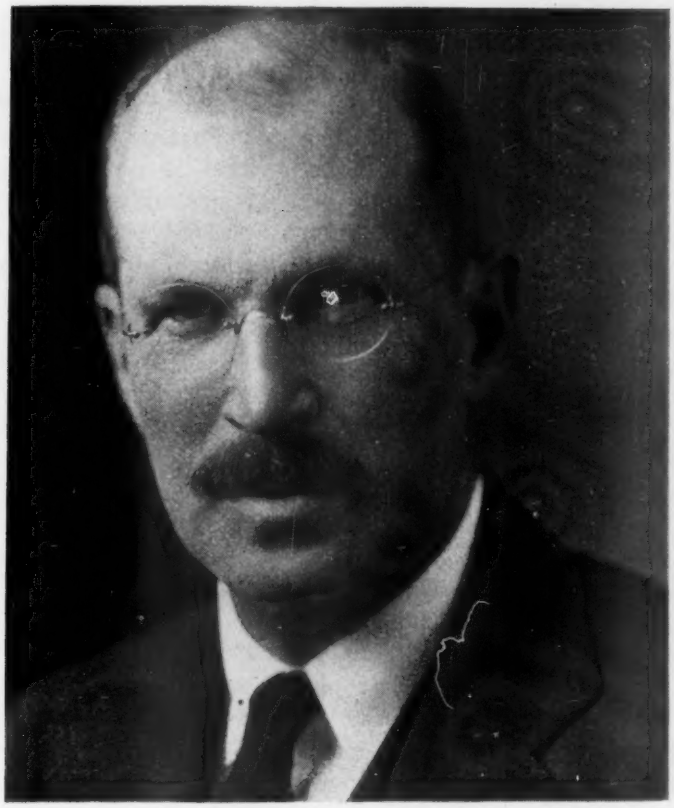
To his wife, his children and grandchildren, he has bequeathed an imperishable inheritance of honesty, intelligence and character far more precious than "towers of gold or pyramids of old."

RUDOLPH MATAS

EDWARD PEIRSON RICHARDSON

1881—1944

Edward Peirson Richardson was born in Boston, April 4, 1881. His father, Maurice Howe Richardson, became Moseley Professor of Surgery at the Harvard Medical School and Chief Surgeon of the Massachusetts



General Hospital. His mother was Margaret Peirson, who came from a prominent New England family, some of whom were physicians and surgeons. Edward, the eldest of six children, decided early to follow in his illustrious father's footsteps. He graduated from Harvard College in 1902 and ranked first in his class at the Harvard Medical School, which gave him a doctor's degree in 1906.

His career was closely associated with the Massachusetts General Hospital and the Harvard Medical School. Working his way from "House Pupil" through the Outpatient Department, he finally in 1927 became John Homans professor of surgery and chief of a surgical service at the

Massachusetts General. These final appointments were on a full-time basis, which meant the abandonment of a very large private surgical practice.

Richardson contributed extensively to the surgical literature. His publications were mainly in journals but include a book, written with J. H. Means as coauthor, on the thyroid gland. He had an interest in all phases of medicine in a broad sense. He performed all surgical procedures with deftness and ease but was particularly interested in abdominal and thyroid surgery.

In addition to the Southern Surgical Association, he was a member of the American Surgical Association, the International Society of Surgery, the New England Surgical Society, the Society of Clinical Surgery, and the Boston Surgical Society.

Richardson was a clear-thinking, observant clinician whose diagnostic acumen was outstanding. He never made a showy impression, keeping in the background, modest to a fault, yet held the profound respect of his associates. He was a natural surgeon, developing a technic of gentleness combined with accuracy and reasonable speed. His teaching was of the type that made students and junior staff listen, since every word carried a knowledge of the literature and from a vast experience he was able to separate important data from the whole.

In 1915, he went to France with the first Harvard Unit No. 22 General Hospital, British Expeditionary Forces. When the United States entered World War I, he served with the American Expeditionary Forces in France and Germany in 1918 and 1919, being honorably discharged with the rank of Major.

In 1917, he married Clara, the daughter of the late Dr. Frederick C. Shattuck—for many years Jackson Professor of Clinical Medicine of the Harvard Medical School and chief of the East Medical Service of the Massachusetts General Hospital. This was a happy union and to them were born three sons: the eldest, bearing his father's name, has graduated from the Medical School and finished part of his postgraduate training prior to entering the Armed Services. Mrs. Richardson's untimely death in 1923 following cesarean section was doubtless a secret source of pain and suffering for Edward, but at no time was this evident to his friends.

Edward gave the impression of a recluse to those who did not know him well. As a matter of fact, he loved life and people and never missed a well-earned holiday with his friends on field and stream or club. He was a fair shot, could throw a fly with expertness, and enjoyed golf. His endurance and lack of apparent fatigue made it difficult for those of us, who saw him daily, to realize that his brilliant career could be cut so short.

At the age of forty-nine, while teaching a group of students, cerebral hemorrhage occurred which disabled him so much that he was not able to take up professional work again. He never regained adequate speech but understood all that was said to him and frequently attended local surgical meetings after his accident. He laboriously taught himself to read again

and to write with his left hand. He took up painting as a hobby, traveled a good deal with his boys, and enjoyed fishing to a considerable extent. He bore his affliction with a fortitude seldom seen. Never a word of complaint was heard nor an impression of bitterness given. This made his friends appreciate more than ever the true worth of the man.

Shortly after a second cerebral hemorrhage January 26, 1944, Edward died. His passing will be long felt by those who knew and loved him. Mankind lost a champion, surgery a great leader, and students a brilliant teacher.

ARTHUR W. ALLEN, M.D.

KENNETH HAZEN AYNESWORTH

1873—1944

DR. KENNETH HAZEN AYNESWORTH, member of the Southern Surgical Association, died October 30, 1944, at the age of 71 years. The cause of his death was apoplexy. He is survived by his widow, Mrs. Maude Brian Aynesworth; two sons, Kenneth H. Aynesworth, Jr., and Major Brian Aynesworth, now serving overseas with the United States Army Corps; two daughters, Mrs. Wilson Crosthwait, of Waco, and Mrs. Thomas Clifton Mann, of Washington, D. C.; and two brothers, Dr. Horace T. Aynesworth, of Waco, and Levan Aynesworth, of Fresno, California.

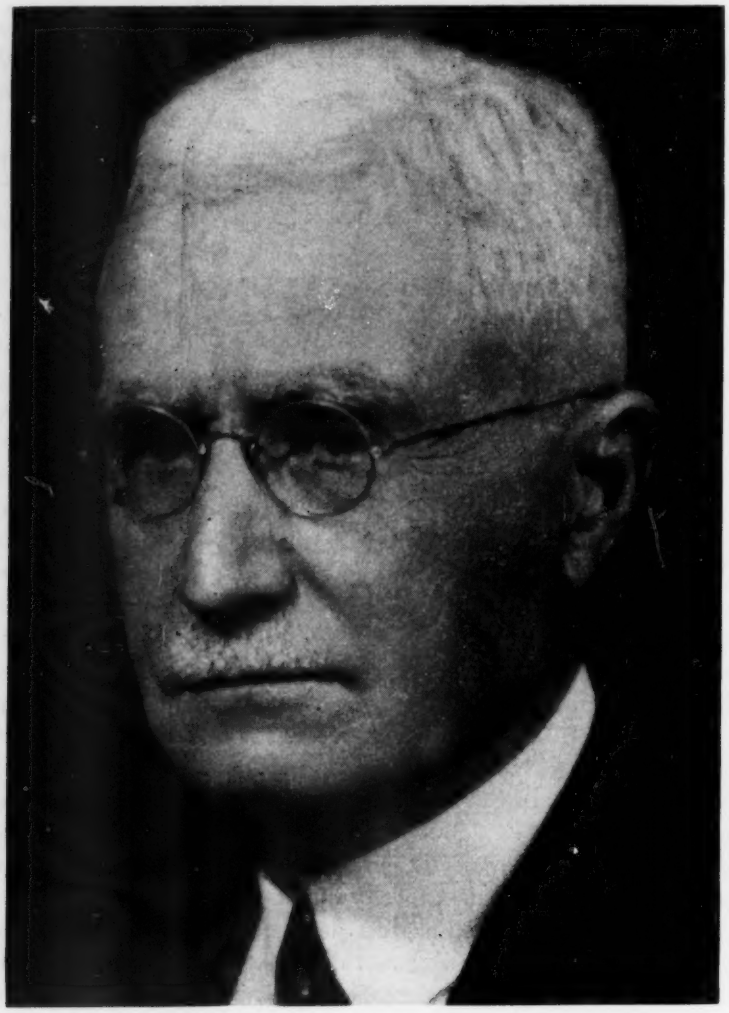
Doctor Aynesworth was born in Florence, Texas, on February 9, 1873. He attended Baylor University at Waco, Texas, and received the degree of Doctor of Medicine from the University of Texas in 1899. He was awarded the honorary degree of Doctor of Laws from Baylor University in 1933. He did postgraduate work in Berlin in 1908–09, and also attended graduate courses at Johns Hopkins.

Doctor Aynesworth began the practice of medicine in Waco, Texas, in 1903, and continued to make this city his home until the time of his death.

Doctor Aynesworth showed a great deal of enthusiasm about everything he did. He was strong in his likes and dislikes. He was active in a number of scientific societies, as well as medical organizations. He contributed a number of scientific papers, including papers read before the Southern Surgical Association.

He had many interests outside of his profession. He was an archeologist of some note and a collector of historical relics, as well as a collector of books and pamphlets on the history of the Southwestern part of the United States. He donated a large and valuable library upon the history of Texas and the Southwest, with many Indian archeological specimens, to Baylor University at Waco. He seemed to care for neither wealth nor fame but was very much in love with his work.

Doctor Aynesworth served on the Board of Regents of the University of Texas for a period of eleven years. He was a member of the American Medical Association, Southern Surgical Association, the American College of Surgeons and the American Board of Surgery. He was one of the



founders and past president of the Texas Surgical Society. He was a member of the Alpha Omega Alpha, honorary medical fraternity, the Texas Academy of Sciences, Texas State Historical Association, West Texas Archeological and Paleontological Association, and founder and member of the Philosophical Society of Texas.

He will be very much missed by the members of the Southern Surgical Association.

ALBERT O. SINGLETON, M.D.

WILLIAM SIMPSON ELKIN

1858—1944

THE INVITATION to contribute lines to the memory of a life-long friend, an intimate professional and business associate, is a duty and responsibility not unmixed with overwhelming personal emotion. This friend is Dr. William Simpson Elkin, born April 26, 1858, in Lancaster, Ky., and who died in Atlanta, Ga., April 24, 1944, almost on the eve of his eighty-sixth birthday.

The son of a prosperous farmer of Garrett County, he was thoroughly prepared to enter Centre College, Danville, Ky., and, in 1879, received his A.B. degree. Three years later, 1882, his medical degree was conferred by the University of Pennsylvania. The rapidly growing City of Atlanta attracted him, and there he made his home until his death.

On October 26, 1887, he married Miss Nellie Duncan, of Lancaster, Ky. Their only child, a son, died in infancy. Mrs. Elkin died January 1, 1934. In October, 1935, he married Mrs. Nell Warren Osborne, of Stamford, Ky., who still survives him.

His nephew, Dr. Daniel Collier Elkin, is now Colonel and Chief of the Surgical Service in the Ashford General Hospital, White Sulphur Springs, W. Va. Doctor Elkin early developed a marked ability as a surgical clinician in the out-patient department of the Southern Medical College. In a few years he was promoted to Professor of Clinical Surgery and attending Surgeon of the Grady Memorial (Municipal) Hospital, of 400 beds. Following the consolidation of several medical colleges, he became Dean of the Atlanta College of Physicians and Surgeons, and from time to time, in conjunction with Dr. Abner W. Calhoun, Professor of Ophthalmology, contributed large sums in support of this institution.

The death of Dr. Hunter P. Cooper in 1906, and coöwner of a private sanatorium, resulted in the formation of a partnership with the writer. He succeeded Doctor Cooper as Professor of Obstetrics and Gynecology. Sensing the spirit of the times, Doctor Elkin envisioned radical enlargement of hospital teaching facilities, and the absolute necessity of becoming an integral part of a virile University. Quietly and alone, he interested the Candler family, wealthy benefactors of the young Emory University (the parent Emory College at Oxford, Ga., 40 miles distant) and, in 1915, the renamed Atlanta Medical College became the Medical School of Emory University. The writer is confident that no other man could have so aroused the enthusiasm and interest in such a huge and mutually advantageous enterprise, in securing donations and an endowment of millions of dollars. Upon his retirement in 1925, the degree of LL.D. was conferred by Emory University, and, in 1929, a like degree honored him by Centre College.

Doctor Elkin was a deacon of the First Presbyterian Church, Director of

the First National Bank, a Mason, a Democrat, and a member of several exclusive social clubs. He was a member of the Southern Surgical Association since 1890, a Founder, in 1913, of the American College of Surgeons, twice past President of the Fulton County Medical Society, and, of course, affiliated with the district, State and National organizations. He enjoyed a handsome income from a large city practice and a State-wide consultation clientele; and by thrift, and unusual business sagacity, amassed a comfortable fortune.

Doctor Elkin's standard of citizenship was high. All worthy religious, civic and charitable projects found his purse open, and he often remarked that it was the obligation of every good citizen to register and vote for the lowest to the highest office. He invariably evinced anger when anyone, legally eligible and physically fit, endeavored to avoid jury duty. There was no personal political ambition in him, although he was often invited to participate in conferences in various legislative bodies because of his unusual sound sense and forthright principles. Golf finally lured him from the exactions of his professional work. His great personal charm and camaraderie in the enjoyment of congenial companionship on the links gave his fellow players unforgettable pleasure.

Other than an occasional trip to Europe and winter cruises in the Caribbean, or a few weeks at Palm Beach, the outstanding event in the last half of his life was the Kentucky Derby week, where for many years he maintained a large box and dispensed gracious hospitality to a wide circle of friends.

The death of Dr. William Simpson Elkin marks the passing of an irreplaceable friend, a wise counselor, and, in the opinion of the writer, the greatest all-around Doctor he has ever known.

WILLIAM S. GOLDSMITH, M.D.

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